STATE OF ILLINOIS

STATE GEOLOGICAL SURVEY

FRANK W. DEWOLF, Director

BULLETIN No. 29

PURCHASE AND SALE
OF
Illinois Coal on Specification

BY

S. W. PARR

Work in cooperation with
Illinois Coal Mining Investigations, and
University of Illinois

ILLINOIS STATE GEOLOGICAL SURVEY
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LETTER OF TRANSMITTAL.

STATE GEOLOGICAL SURVEY,

UNIVERSITY OF ILLINOIS, OCTOBER, 15, 1914.

Governor E. F. Dunne, Chairman, and Members of the Geological Commission.

GENTLEMEN: I submit herewith a report by Prof. S. W. Parr of the University of Illinois, Consulting Chemist of the Geological Survey, entitled: "Purchase and sale of Illinois coal on specification," and recommend that it be published as Bulletin No. 29.

This subject is one of growing interest to producers, sellers, and users of Illinois coal; and Professor Parr's work as a pioneer investigator has commanded respect everywhere.

The report reviews some of the work published by the Illinois Coal Mining Investigations, Cooperative Agreement, as well as extensive experiences in purchase of coal by the State Board of Administration, to both of which organizations we are greatly indebted.

Very respectfully,

FRANK W. DEWOLF, *Director*

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ILLUSTRATIONS.

THE PURCHASE AND SALE OF ILLINOIS COAL ON SPECIFICATION.

By S. W. Parr.

INTRODUCTION.

Increased Use of the Heat-Unit Basis.

Information concerning the composition and properties of Illinois coal is in constant and growing demand. Requests for such information come from many market centers and are by no means confined to the State of Illinois. They represent specifically the needs of the community at large, and are perhaps characterized chiefly by the fact that they indicate a marked tendency on the part of users of coal to scrutinize all available data with the ultimate purpose of making their purchases of this commodity on some basis other than that of simple tonnage. The coal operators are not so eager in this movement for the obvious reason that the mining of coal must be paid for by the ton. It does not simplify the lot of the coal producer, therefore, to be obliged to pay for mining the output on a weight basis, and to sell the product on an entirely different basis. Here again, it is believed that a fuller knowledge of the facts relating to the composition of Illinois coals will materially reduce the prejudice of the operator and be of assistance in the making of fuel contracts by enabling him to formulate his proposals more intelligently.

It is inevitable that large users of coal will insist more and more upon contracting for their fuel supplies on some basis other than that of a set price per ton. In spite of certain objectionable features and some opposition, which is not without cause for its existence, there is evidence of a steady increase in the use of what is generally termed the "heat-unit basis" for the purchase of coal. A simple illustration may serve as an explanation of this tendency: Three Illinois state institutions with substantially the same shipping rate received bids on coal supplies from dealers A, B and C, their respective prices being $1.15, $1.72 and $1.43 p ton. Now, as subsequently proved to be the case, A was able to deliver, and did deliver, coal with an ash and moisture content of 21 per cent and a heat-unit value which entitled him to a settlement price under the contract of $1.55 per ton. The deliveries by B, contained an ash and moisture total of 30 per cent and a heat-unit value which resulted in a settlement price of $1.12 per ton. Similarly, C with a total ash and moisture content of 33 per cent was entitled to a settlement price of $0.97. These items are more conveniently shown in tabular form thus:

TABLE 1.—*Difference between the estimated and actual value of coal.*

Bidder	Total per cent of non-combustible in coal as delivered	Bidding price	Settlement price	Difference
A	21	$1.45	$1.55	$0.10
B	30	1.72	1.12	0.60
C	33	1.43	0.97	0.46

It is seen from this table that dealers A and C estimated their coals at substantially the same price, say $1.45 per ton. The intrinsic values, however, which are at least relatively indicated by the settlement price, are shown to have a difference of substantially 60 cents per ton. Similarly, dealer B, who estimated his coal as worth $1.72 per ton finds its actual value, or at least its settlement value according to the terms of the contract, to be $1.12 or 60 cents less per ton. The table shows also that a dealer may name his price per ton with very little knowledge as to the intrinsic value of the material. There is little if any relation between the price asked and the actual heat value to be delivered. Illustrations of such discrepancies could be multiplied indefinitely.

Opportunity for Securing Data.

During the year 1912 the Illinois Coal Mining Investigations, Cooperative Agreement, sampled over 100 mines at three or more widely separated working faces. This work has afforded an unusual opportunity for studying sampling and analytical methods and also for making a comparative study of the variables and constants in individual mines or districts. Furthermore, the writer has been in charge of coal inspection and analysis as conducted for several years by the State Board of Administration with a view to business-like purchase of coal for the State Charitable Institutions. Similarly, a great mass of data has come into our possession through the purchase of coal on specification by the University of Illinois for many years.

It is the purpose of this report to present such results and data as may have a direct bearing upon the methods of inspection and the purchase and sale of coal by contract.

PRINCIPLES OF COAL SAMPLING.

Care in Sampling.

Without question, the critical point in the entire range of coal inspection and analysis is in the sampling. If the sample taken is truly representative of the entire lot, the results, if accurate in themselves, furnish correct information as to the larger mass of which the sample is a part. If, on the other hand, the sample is in error, the results of the analysis though correct in themselves will be in error so far as they relate to the mass under consideration. Throughout the process of sampling two points must be observed with scrupulous care:

> First—The sample taken must be representative of the whole, that is, the distribution of the various substances which go to make up the original mass must be maintained without any change in the relative amount of the various constituents.
>
> Second—The moisture content, which changes readily, must be under exact control so that at any stage the ratio of moisture present to the original moisture of the mass may be definitely known.

A Representative Sample.

MATERIAL TO BE TAKEN.

As stated above, the first essential in a sample is that it shall truly represent the mass of which it is a part. To secure this result a few fundamental conditions must be observed, as follows:

The gross sample must be representative of the various kinds of material present. That is to say, a mass of coal conists of fine stuff, lump, bone, slate, pyrites, and other constituents. As a rule the "fines" differ in composition from the lump, hence the sample must have these two sorts of material in their proper proportion. The same is even more true of slate or pyrites, of which the composition differs so widely from that of the major part of the mass. An undue amount of such material would cause a serious disturbance in the accuracy of the sample.

AMOUNT.

In procuring a representative sample a large element of safety resides in the quantity taken. In general, the larger the amount, the more representative it will be. However, conditions differ. It is easier, for example, to procure an even sample from the face of a working vein or from a carload of screenings than from a carload or other mass of lump or of run-of-mine coal. In the latter cases larger amounts should be taken than in the former.

The limits of practicability for the proper handling of the sample must however be considered. In general, the gross sample should weigh approximately from 200 to 600 pounds. Doubtless 200 pounds of screenings, taken with fairly good distribution throughout the unloading of a 40- or 50-ton car, will yield a very true sample. The difficulties increase greatly with the increase of the size of the particles, as in the case of lump or mine-run coal. If mechanical appliances for grinding are available, the larger amount should be taken, but a smaller sample well crushed down before quartering is better than a greater mass quartered down while the particles are still in larger pieces.

RATIO OF SIZE TO MASS.

Assuming that the sample as taken is made up of the various kinds of material in proper proportion, the next important item is to maintain these variables in their ratios throughout the process of reducing the gross amount to a small working or laboratory sample. To insure this result, there must be maintained a certain ratio of size of the particles to size or weight of the mass. This, as a rule, is based on a formula which provides that the weight of the largest piece of impurity shall have a ratio to the weight of the mass of about 2 : 10,000. For example, a mass weighing 10,000 grams, or about 22 pounds, should contain no particles weighing more than 2 grams. This would mean that the largest particle, as for example, a piece of iron pyrites, must not be over ¼ inch in its greatest diameter.

The final ratio of sizes, however, should be determined by the methods available for grinding. With mechanical appliances for obtaining the smaller sizes, a table of ratios with greater safety limits can be adopted than is perhaps practicable where the crushing is done by hand. If a power crusher is available, the entire sample should be passed through the mill and reduced to a size which will pass a ¼-inch screen. If the crushing must be done by hand, the first reduction in size of the particles should be such that the entire mass will pass through a 1-inch screen. When by quartering, the sample is reduced to 100 pounds, the size of the particles should be further reduced to a size that will pass a ½-inch screen, and with a 50-pound sample in hand the crushing should be carried to ¼-inch mesh. The subdivisions with their respective sizes are shown in tabular form as follows:

TABLE 2.—*Size of mesh for different subdivisions of sample.*

Weight of subdivisions of sample (pounds).	Size of mesh to which each subdivision should be broken (inches).
500	1
250	¾
125	½
60	¼
30	⅛

MILL FOR CRUSHING.

Illinois coals are easily crushed in mills which are available at little expense. Hence it is entirely reasonable to require that gross samples, when reduced in mass to 50 or 75 pounds, shall be passed through a mill set for grinding to approximately ⅛ inch. For this work, a mill which

Figure 1—GRINDING SURFACES OF COAL CRUSHER.

is not of the jaw-crusher or roller type is preferred, since these types produce too large a percentage of fine material, and the harder pieces of slate, especially those of flaky or plate-like structure, are liable to pass in pieces having inadmissably large dimensions in two directions, even though the adjustment used would seem to be fine enough to prevent the passage of such material. A grinder of the coffee-mill type or one with projecting teeth on the grinding surfaces will be found to produce a more uniform size and the minimum amount of dust. The grinding surfaces of such a machine are shown in figure 1, and the same type of mill is shown set up in figure 2.

MIXING AND SUBDIVIDING.

As a further precaution in maintaining a correct distribution of the various constituents, emphasis is placed upon the necessity of thorough mixing, followed by even selection of the remaining subdivisions. It is true that fine grinding contributes materially to this end but further care is necessary. It is entirely practicable to mix a 50-pound sample,

Figure 2.—COAL GRINDER OF THE COFFEE-MILL TYPE.

ground as above described, by rolling in an oilcloth about five feet square. This is accomplished by taking one corner of the cloth and carrying it over the pile towards the diagonally opposite corner so as to cause the mass to roll over upon itself, then reversing the motion and repeating the process with the other two corners. Fifteen or twenty such alternations, depending somewhat upon the size of the sample, should be sufficient to effect an even mixture. Where available, however, especially in commercial sampling, a mixer is to be preferred. Such a device is most conveniently made in the form of a drum having cone-shaped ends capable of being closed air-tight, and mounted so as to revolve endwise. (See figs. 8 and 9).

The subdividing of the larger sample, to reduce it to a convenient size for transmission to the laboratory, requires special consideration as having an important bearing on the maintenance of the correct ratio of constituents. This may be best shown by the data given in Table 3.

Note in this table that series 1 and 2 are 3-pound samples taken by subdividing in the same manner the same gross sample of about 30 pounds. Each sample was ground to 8-mesh and sized. It will be seen that in series 1, duplicates *a* and *b* had 16.6 and 13.7 per cent of the 60-mesh size, whereas in series 2 the duplicates *a* and *b* had 22.5 and 23.1 per cent respectively. Note further the great increase in ash in the fine size as compared with the ash in the coarse material. For example,

TABLE 3.—*Ash variations in different sizes obtained from duplicate 3-pound samples.*

Series	Mesh	Duplicate halves	Per cent of each size	CO_2 in "dry coal"	Ash corrected for CO_2 in "dry coal"	*a* and *b* composited by calculation
1_1	On 20	*a*	41.7	.40	14.11	
		b	48.4	.37	14.00	
1_2	Through 20 On 60	*a*	41.7	.85	15.55	
		b	37.9	1.00	15.42	*a*......16.32
						b......15.86
1_3	Through 60	*a*	16.6	1.31	23.89	
		b	13.7	1.38	23.65	Average..16.09
2_1	On 20	*a*	29.1	.53	15.91	
		b	25.0	.46	15.68	
2_2	Through 20 On 60	*a*	48.4	.94	16.23	
		b	51.9	.98	16.06	a......17.90
						b......17.80
2_3	Through 60	*a*	22.5	1.32	24.09	
		b	23.1	1.28	23.98	Average..17.85

series 1 having an average of 14 per cent of ash in the coarse size has an average of 23.75 per cent in the fine portion. A similar increase in ash is seen in the corresponding sizes in series 2. The ultimate ash average for series 1 is 16.09 per cent and for series 2 it is 17.85 per cent. These values vary consistently with the variation in the percentages of fine material in the respective series. On the other hand, the duplicate halves *a* and *b* throughout, because of their uniformity resulting from the sizing process, show results in the several pairs which check very closely.

The values as presented in the table, therefore, show clearly that in the process of subdividing the gross sample and in the further reduction of the sample as received at the laboratory, great care must be exercised to see that no part of the manipulation is of such a nature as will promote segregation of the constituents.

A riffle constructed according to the pattern shown in figure 3 may be used to advantage after the sample has been reduced by quartering to about 30 pounds. At this stage the sample is ground to ⅛-inch size, hence the riffle openings may be ½-inch in width. With this variation in the openings the riffle as shown in figure 3 is substantially the one described in the Bulletin of the Ohio Geological Survey, No. 9, p. 313, 1908.

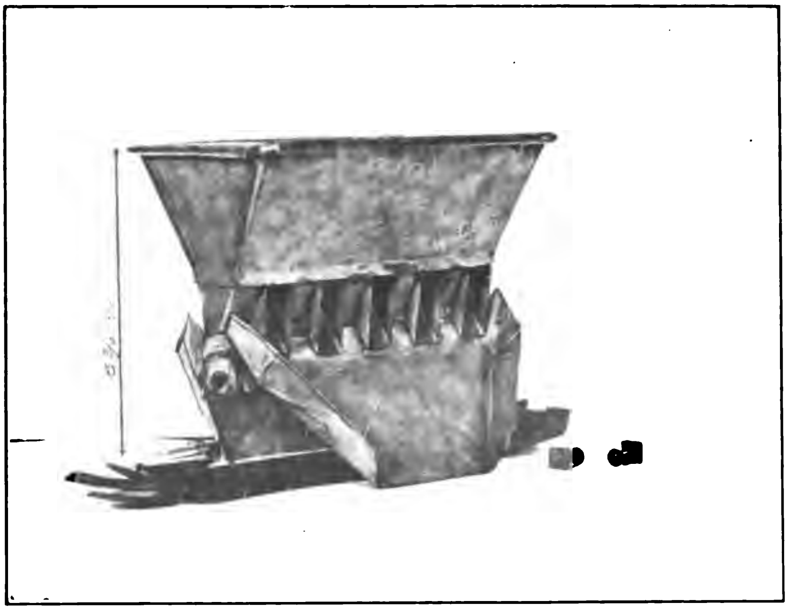

Figure 3.—RIFFLE.

MOISTURE CONTROL.

The second essential in taking and preparing a sample relates to the free moisture present, and requires that the changes in moisture content "must be under exact control so that at any stage the ratio of the moisture present to the original moisture of the mass may be definitely known."

CONDITIONS THAT FACILITATE THE LOSS OF MOISTURE.

In coals of this region especially, where the moisture in the coal as it comes from the mine averages from 10 to 15 per cent the tendency toward moisture changes is very marked. For example, the process of crushing down the larger sizes affords an opportunity for the escape of moisture. Again, if the coal is spread out on the floor of a hot boiler room or left exposed to currents of air for any length of time there will be a serious change in the moisture factor. Another practice sometimes followed is that of assembling the various increments of the gross sample in a sack or other receptacle permitting a relatively free transmission of air. Samples kept in this manner for any length of time or shipped in such containers will have a moisture content quite different from the original.

PRECAUTIONARY MEASURES.

The methods employed, therefore, in collecting and reducing a gross sample must have special reference to this tendency on the part of the free moisture to escape. The work should be done rapidly in a room at or below the normal temperature and, so far as possible, with the use of closed apparatus which admits of the least possible exchange of the contained air. Precautionary measures of this sort should be made at the very outset. The gross sample, which is made up of small increments collected usually over a considerable length of time, should be enclosed in a tight box or clean garbage can having a tightly fitting cover which can be closed and locked against the possibility of change until the time for grinding and reducing.

ILLUSTRATIVE METHODS OF COAL SAMPLING.

Face Sampling.

Since the procedure for obtaining the face samples described in this report serves as a good illustration of methods adapted to meet the principles above enumerated concerning the uniformity of composition and control of moisture, the details of the process for collecting, and subsequent preparation for shipment in the small container are here given in full. The methods thus described are applicable in principle to the collection of any and all samples from whatever source.

DIRECTIONS FOR COLLECTING FACE SAMPLES IN THE MINE.[1]

Selection of the face

Choose three faces in the mine as widely separated as possible in order to give a good average of the coal for that mine. An attempt should always be made to get faces which have not been exposed more than 48 hours.

Preparation of the face

(a). Fresh faces

1. With a pick remove all loose coal (that which sounds hollow when tapped with the pick) and square up the face.
2. Brush off the loose coal, dust and powder stains from the face for a distance equal to the length of the blanket (5 to 7 feet).

(b). Exposed faces

For exposed faces the procedure is the same as above, except that before brushing the face, a strip of the coal one to two inches in

[1] Substantially as given in Bureau of Mines Technical Paper No. 1 with the exception of the preparation, grinding, etc., of the sample.

thickness and about a foot wide is cut down the full vertical height of the face. This is done to give a comparatively fresh face for the sample.

Cutting down the sample

1. Spread the blanket at the base of the clean portion of the face, taking care that it fits close at the bottom.
2. With a pick cut down a strip of coal six inches wide and two inches deep, the full vertical height of the seam. At least six pounds of coal should be cut down for each foot in thickness. All partings of sulphur, bone or slate over ⅜ inches thick are rejected as these are supposed to be thrown out by the miner.

Preparation of the sample

1. The blanket containing the sample as cut down should be spread upon a smooth hard place on the floor and the lumps all cracked

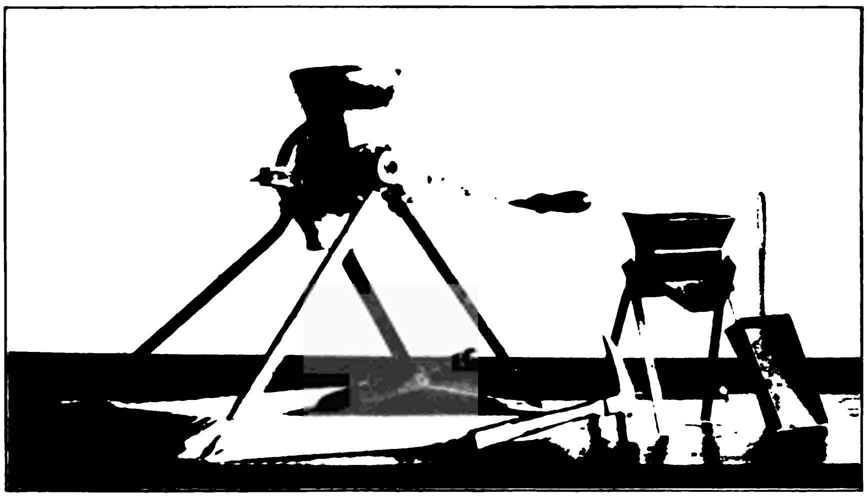

Figure 4.—SAMPLER'S KIT.

down with a pick to a size suitable for readily passing into the grinder. This can be done directly upon the blanket.
2. Pass all of the sample through the grinder.
3. The sample is then riffled down until just enough remains to fill the sample can when the material is well shaken down and the can filled full so as to displace as much air as possible.
4. After filling as indicated under (3) the can is sealed with electrician's tape.

SAMPLER'S KIT.

The sampler's kit is shown in figure 4. The outfit together with sample cans and labels make up a total weight of 23 to 25 pounds.

Where a portable mill is not available the crushing of the larger lumps must be accomplished by tamping. This is a slow and tedious process. With the mill, the grinding of the average gross sample can

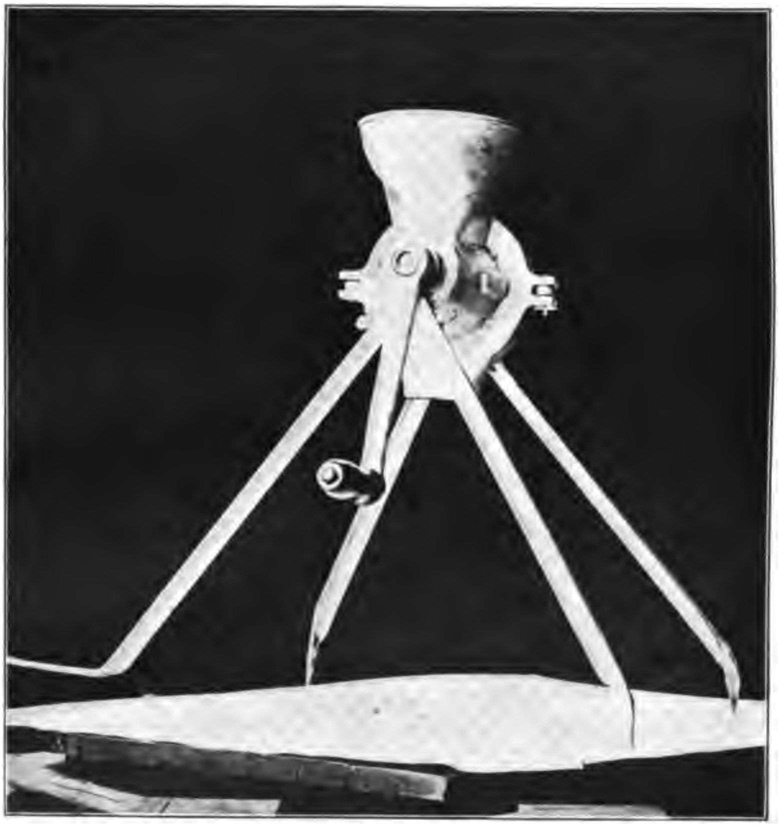

Figure 5.—COAL GRINDER SHOWING METHOD FOR ATTACHING LEGS.

be accomplished in thirty minutes. The mill employed in this work was of cast aluminium except the grinding parts and supports, and weighed complete about 18 pounds. The method of assembling and operating is shown in figures 4 and 5.

By the use of this outfit a 5-pound sample in the best possible condition as to size, evenness of mixture, and accuracy of moisture content, is obtained. Where power and the mechanical accessories are available the time required for delivering the 5-pound sample may be further reduced by one-half or more.

SHIPMENT OF SAMPLE.

After thus reducing the sample to about five pounds, it is placed in a can, such as is shown in figure 6, and forwarded to the laboratory. The particular feature of the container is the skirted screw cap, which by use of electrician's tape wound about the base of the cover affords further security in sealing. On the inside it should contain a suitable ticket giving all the necessary data.

Figure 6.—CONTAINER FOR COAL SAMPLE.

SAMPLES TAKEN FROM COMMERCIAL SUPPLIES.

USE OF GRINDER AND RIFFLE.

It should be a comparatively simple matter at any power plant to duplicate in principle the methods for sampling at the mine, and even to improve the conditions for preserving the moisture values. The first essential is a power mill through which the entire gross sample can be quickly run. An illustration of such an equipment is shown in figure 7.

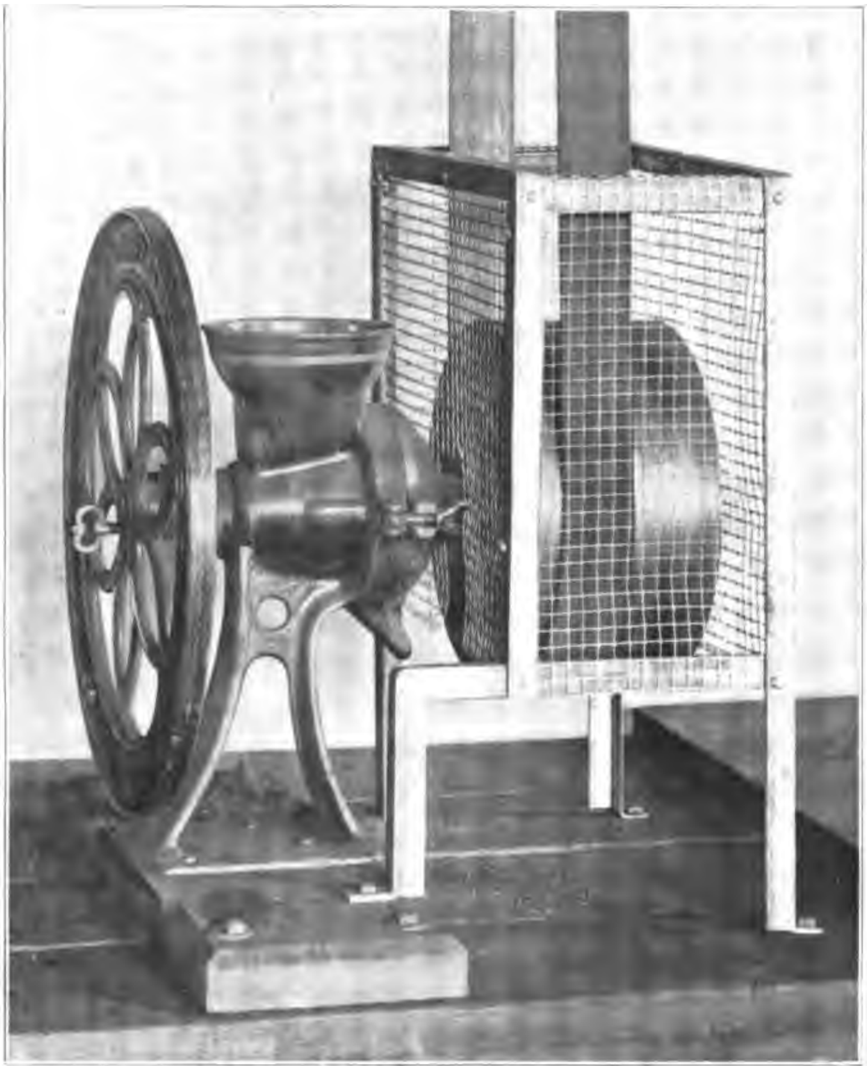

Figure 7.—EQUIPMENT FOR GRINDING COMMERCIAL SAMPLES.

In place of the blanket for rolling the samples, a closed mechanical mixer, such as is shown in figures 1 and 2 is preferred.

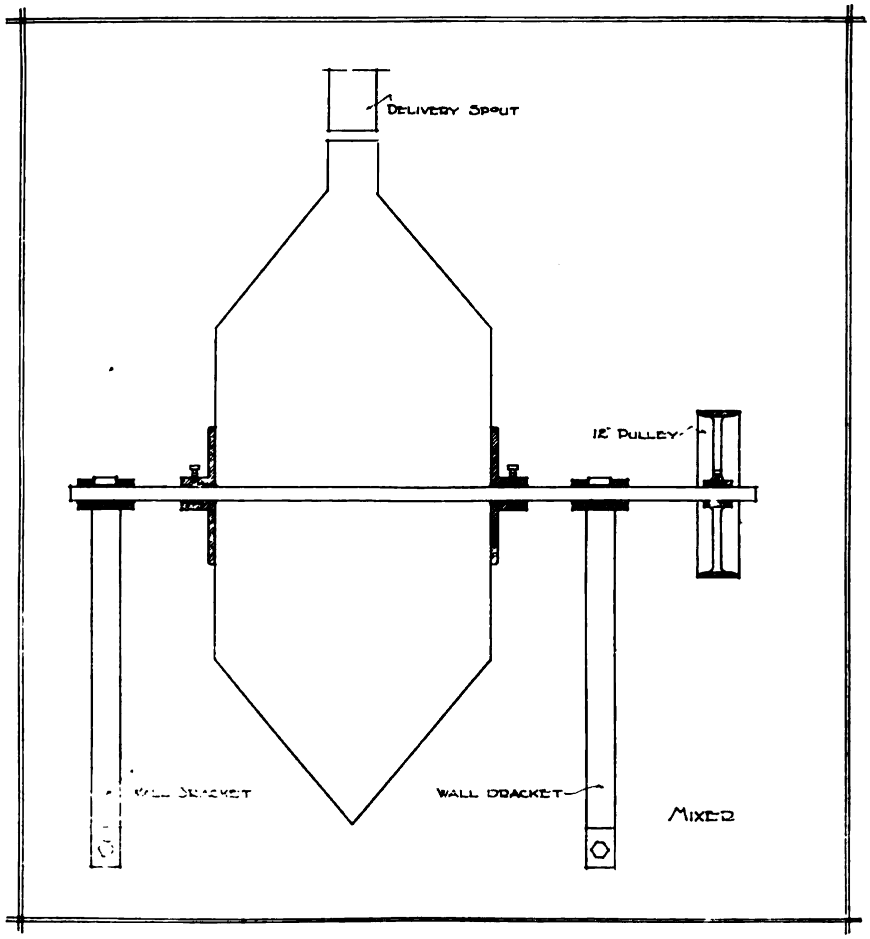

Figure 8.—CLOSED MECHANICAL MIXER.

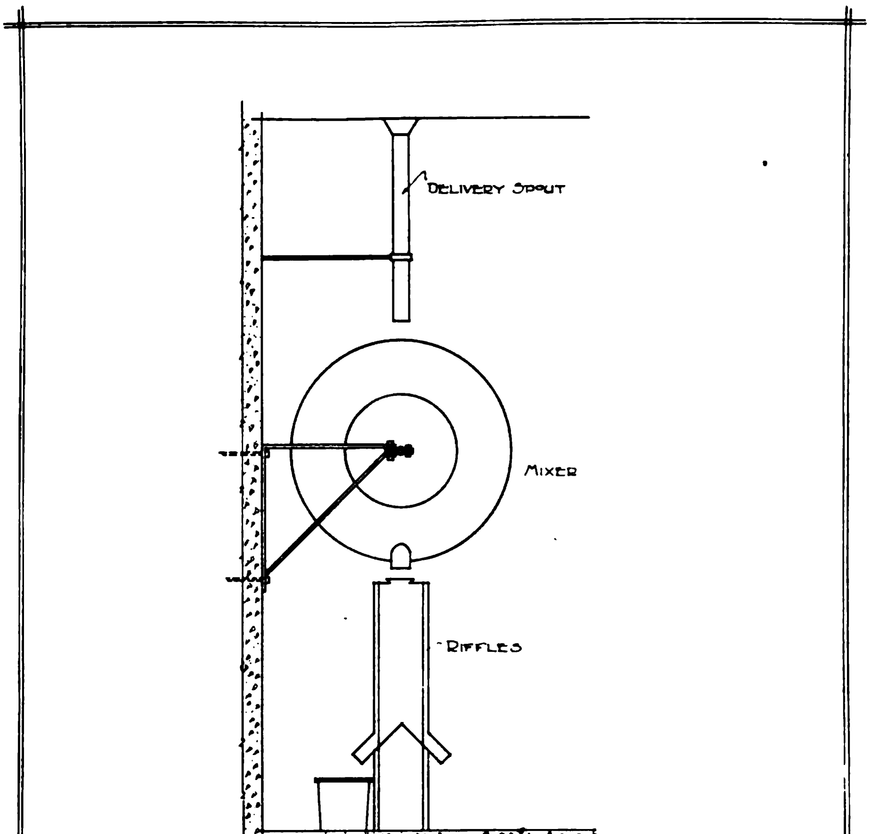

Figure 9.—SIDE VIEW OF MIXER.

The next essential is some form of automatic riffling device, and here it is possible to improve upon the field apparatus by enclosing a series of riffles in a chute thus reducing the accessibility of air currents and other drying conditions. Such a device is shown in diagrammatic form in figure 10. Specific conditions under which samples are most frequently taken are discussed below.

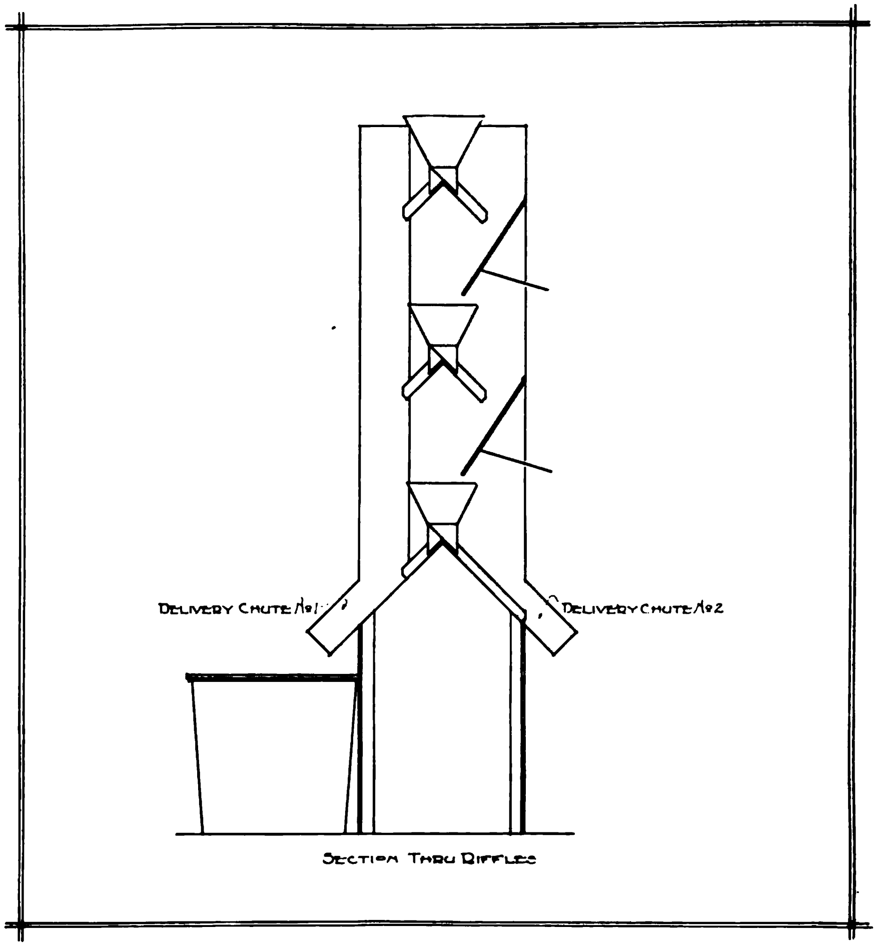

Figure 10.—AN AUTOMATIC RIFFLING DEVICE.

SAMPLING THE CAR DURING UNLOADING.

A car of coal may be sampled to the best advantage in the process of unloading. An occasional half shoveful should be thrown into a proper receptacle (see page 17) so that by the time the car is unloaded approximately 200 pounds, evenly distributed throughout the load will have been taken. This will mean about one-half shovelful for every ten full scoops. They are best taken in the process of shoveling from the bottom of the car, since the top coal rolls down and mixes fairly evenly with the bottom. It should be kept in mind that in taking a sample there must be obtained the different sizes of coal, fine and coarse in their proper proportions from the entire cross-section of the mass, and also an even distribution of the same lengthwise of the car. Even greater care must be taken to guard against loss of moisture in the process of collecting and in reducing the gross sample for the reason that as a rule the relative humidity outside of the mine is lower and the tendency of the moisture to leave the coal is correspondingly increased.

SAMPLING THE CAR WITHOUT UNLOADING.

It has been shown in Table 3, that the finer particles of a coal mass are higher in ash and hence have a greater specific gravity. They are therefore more likely to separate by gravity from the coarser material. On this account, if a car is to be sampled without unloading, it is necessary to dig well toward the bottom in order to obtain a representative sample. Three trenches should be dug crosswise of the load, one near each end and one near the middle of the car. These trenches should go down nearly to the bottom of the mass and each size be taken as nearly as possible in its proper proportion. Lump and run-of-mine lots are much more difficult to sample than screenings, but it should be noted that screenings may vary greatly, for not infrequently a car is partially loaded from one bin and finished from another which may be of a different size and composition. After obtaining the gross sample, the methods to be followed are the same as those already given.

COMPOSITE SAMPLES.

It is often desirable to composite a number of samples. In this way a single sample may be made to represent a much larger quantity of coal and thus cut down the time and expense involved in procuring the analytical data. In this procedure, however, it must be remembered that even greater care should be exercised in taking the several component samples. The amount of each sample entering into the composite must be in proportion to the mass which it represents, and finally a thorough and positive mixing of the composited mass must be effected before riffling down the same to the usual 5-pound quantity.

It is convenient to determine the amount of each sample to be taken by employing an aliquot system of weights. For illustration: Suppose we adopt 1 gram to the 100 pounds as the unit which shall enter into the composite. Then a 100,000-pound car of coal should be represented by 1,000 grams. In compositing, therefore, the entire content of each can will not be taken, but instead an aliquot proportion which will give to each car lot its due amount. It is preferable to use such a factor as shall utilize the major part of the several 5-pound samples. In this way the gross composite from 10 cars would aggregate 20 or 30 pounds in weight. It should be put into the mixer and revolved until a thoroughly homogeneous mass is obtained and then riffled down to a 5-pound sample as already described. For this procedure it is obvious that the necessary data should accompany the various samples. A ticket inserted in the can before sealing should give the data needed. The form shown below will be found suitable.

DUST OR DUFF DETERMINATION.

Specifications usually prescribe the maximum amount of dust allowed. This is designated as the material which will pass through a screen with ¼-inch openings. Obviously this item is not taken into account in mine samples, but should be determined in samples taken from commercial supplies. A determination of the percentage of dust is best made on one of the rejected quarters of the first subdivision. For example, a gross sample of 200 pounds is mixed and quartered. One of the quarters is taken and weighed. This is screened by shaking small portions at a time in a sieve with ¼-inch openings, preferably a sieve with circular perforations ¼-inch in diameter. The fine material is collected and weighed. These two weights together with the other necessary data as above noted should be entered on a ticket and enclosed in the shipping can. A suggested form for this information is as follows:

Received by..............................

Date ....191....

Car initial and number..

Weight of car content...

Weight of quarter for dust determination......................................

Weight of dust net..

Shipping point*...

Shipper or dealer...

*Where bill of lading is accessible the place from which shipment is made should be indicated.

The assembling of the data thus supplied by the several shipments should be made in tabular form at the laboratory. A sample will illustrate further the method of keeping the record and the use made of the data in compositing the final sample.

FUEL LABORATORY REPORT.

University of Illinois.

Label..................

Sample of.................... From..............................

User.

Lot No.	Car Initial	Car No.	Source: Mine or operator	Weight of Car content	Weight of quarter taken for dust determination	Weight dust: net	Sampled by	Date of sampling
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Size mesh before 1st quartering........................Size mesh for composite........................

Composited by........................Date compositing................Wt. of composite........................

Report of Analysis

Air-dry loss ....% Laboratory No. ....

	Proximate Analysis			"Unit coal" (moisture, ash and sulphur free) N. F.
	Coal "air dried"	Coal "as received"	Coal "moisture free"	
Moisture..................				
Volatile matter......				
Fixed carbon..........				
Ash............				
Total..................				
Sulphur..................				
CO_2..........................				
Dust..........................				
Calorific value determ. { Calories				
B.t.u.				

Reported.................................191...... Analyst...

....

TABLE 4.—*Data for compositing 10 samples.*

Laboratory No. 6280.

From—Watertown State Hospital.

Lot No.	Car initial	Car No.	Source: Mine or Operator	Date of taking sample	Weight of car content (pounds)	Weight taken for the composite (grams)	Weight of quarter taken for dust determination (pounds)	Net Weight dust (pounds)
1	M.C.St.L.	384979	A & B	1/22/13	69400	694	50	10
2	do	20313		1/24/13	88100	881	50	10
3	do	12201		1/22/13	56100	561	50	8
4	M. O.	12935		do	86200	862	50	7
5	C. I. M.	657		do	86700	867	50	8
6	M. C. R.	358482		do	49400	494	50	6
7	do	4288		1/24/13	69100	691	50	8
8	I. C.	14027		1/22/13	87100	871	50	12
9	do	13654		do	87700	877	50	6
10	L. S.	34081		do	84600	846	50	10

Composite Total—7644.

MOISTURE CHANGES.

Moisture Conditions and Nomenclature.

The topic of moisture control has already been discussed, emphasis having been laid upon the fact that at any stage of the processes the exact ratio of the moisture present to the moisture of the original mass must be definitely known. This implies that moisture changes do occur. Indeed three moisture conditions exist and, since under each condition all of the accompanying factors are modified to meet the specific change in moisture, a special designation is applied to the coal for each one of these conditions.

Coal with all of the normal moisture present is designated as "wet" coal or coal "as received." It relates to the moisture at the time of taking the sample. All of the detail of the processes for collecting and reducing the gross sample up to and including the item of sealing and shipping the 5-pound sample involve the preservation of this initial moisture without loss.

The second moisture status is that wherein the "wet" or "as-received" coal has been dried to a point of substantial equilibrium with the moisture of the air, so that in an atmosphere of average humidity it would take on or lose additional moisture very slowly or not at all. In this condition the coal sample is said to be "air dry." This is the condition to which the chemist must bring the sample in order that the processes of finer grinding and weighing may be carried on without change in the moisture factor. Obviously the amount of moisture lost in passing from the "wet" or "as-received" condition to the "air-dry" condition must be carefully measured. The factor thus determined is designated as the "loss on air drying." By use of it all of the values obtained from analysis of the coal in the "air-dry" state may be calculated to the "wet" or "as-received" condition.

The third condition recognized is that of "dry" coal. This is sometimes designated as the "oven-dry" or "moisture-free" state. All of the values found for the coal in the "air-dry" condition may be transferred by calculation and made to apply to the coal as "oven dry." The necessary factor in this case is the loss of moisture obtained from drying the "air-dry" sample at or slightly above steam temperature, as 220°F. for one hour. It is not intended here to give directions for carrying out these processes. The terms employed, however, are of so frequent occurrence, and in many cases enter so vitally into a correct understanding of the methods upon which certain values are based in the making of estimates and arriving at fuel settlements that at least a brief reference seems desirable.

CALCULATIONS.

To calculate the percentage values obtained on "air-dry" coal to the "dry-coal" basis, divide each constituent by $(1-w)$ in which w is the moisture present in the "air-dry" sample. The moisture factor for the "dry" coal is omitted of course, and the sum of the resulting constituents should total 100 per cent.

To calculate from the "air-dry" values to the "wet," or "as-received," condition multiply each percentage for the "air-dry" state by $(1-l)$ in which l is the loss on air drying. The moisture factor thus derived plus the loss on air drying equals the total moisture in the "wet" coal. This and the other factors calculated as described should equal 100 per cent.

COMMERCIAL VALUATION AS AFFECTED BY CHEMICAL AND PHYSICAL PROPERTIES.

MOISTURE.

RELATION OF COAL-BED MOISTURE TO COMMERCIAL MOISTURE.

In comparison with Eastern and European coal the coal-bed moisture of coals of the Illinois type is high and requires special consideration for a proper understanding of many conditions surrounding the handling of this material.

In perhaps the majority of cases coal is purchased on the basis of its weight at the mine. As a rule, the first purchaser, at least, is obliged to make settlement on the basis of what is known as the railroad or mine weights. Accordingly the total moisture as found in the vein sample probably represents as accurately as is possible the moisture condition of the coal as weighed in the loaded cars just before shipment from the mine. The chipping, grinding, and riffling process, it is true exposes the coal for about an hour and subjects it to the possibility ot a slight loss of moisture; so also does the process of breaking out, loading, hauling, hoisting, and screening, require a number of hours. These two lots, therefore—the coal-bed sample and the car ready for market—are represented practically by the same moisture factor. This would be a reasonable conclusion on theoretical grounds alone, but it is supported also by experimental results, though more data might be desirable on the point.

In the table below are given moisture figures obtained on coal-bed samples taken in the usual manner as described above, and, for comparison, in the same column are given the moisture amounts for coal from the tipple or chutes as it passed to the railroad cars. These results show a very close agreement in the mine-run and screened-lump samples. The greatest variations would be expected in the screenings where the floor material and other foreign matter enter into the output, but even here the agreement is quite close.

TABLE 5.—*Moisture in face samples compared with moisture in shipping samples taken at the mine.*

Lab. No.	County	No. of coal bed	Moisture in face samples (per cent)	Moisture in commercial samples		
				Screened lump (per cent)	Mine run (per cent)	Screenings (per cent)
5130	Sangamon..	6	15.22		14.75	
5131			13.10		14.14	
5132			14.43			
			Av.—14.25		14.44	
6016	Macoupin..	6	14.29		13.40	13.79
6017			15.51		13.39	
6018			13.81			
			Av.—14.54		13.39	13.79
5517	Madison...	6	12.44	11.89		12.41
5518			12.11			13.42
5515			13.88			
			Av.—12.81	11.89		12.91

TABLE 5.—*Moisture in face samples compared with moisture in shipping samples taken at the mine.*—Concluded.

Lab. No.	County	No. of coal bed	Moisture in face samples (per cent)	Moisture in commercial samples: Screened lump (per cent)	Mine run (per cent)	Screenings (per cent)
6023	Madison...	6	12.52	11.99	10.09	11.78
6026			12.71			
			Av.—12.61	11.99	10.09	11.78
5988	Williamson.	6	9.76		7.92	8.25
5990			8.28		7.40	
5993			8.72			
			Av.— 8.92		7.66	8.25
5984	Williamson.	6	7.86		7.17	8.73
5991			6.95		7.45	
5983			8.08			
			Av.— 7.63		7.31	8.73

LOSS OF MOISTURE ON SHIPPING.

In the process of shipping and marketing coals of the Illinois type there is frequently a shrinkage in weight due to the loss of the excess moisture. This may be from 2 to 4 per cent of the gross weight, depending upon weather conditions, the length of time in transit, and other factors. This shrinkage in weight, however, is not a real loss, since increase of the heat value per pound is almost directly proportional to the loss of moisture. When screenings are subjected to extreme weather conditions, such as heavy rains, snow, or sleet, there may indeed be a gain in weight instead of a loss. Obviously this high moisture is a disturbing element, and much more so with coals of this type than with those of the eastern bituminous variety, where the coal-bed moisture does not vary widely from the amount which would be in practical equilibrium with the moisture of the atmosphere.

To illustrate the amount of variation in moisture due to weather conditions there is presented below the average of a number of moisture values on shipments received at the University of Illinois steam-heating plant during approximately four years and coming from two distinct fields. It is to be noted that shipment from the Danville district is direct. The distance is about 30 miles, and the time between the breaking out of the coal at the working face to the delivery and sampling at the power station was not more than two or three days. The distance from Christian County is approximately three times as great, and shipments consume on the average two or three times the length of time in transit.

TABLE 6.—*Moisture values in commercial samples at point of delivery compared with coal-bed moisture.*

(All samples made on screenings.)

Table No.	County	Dates covered by shipments	No. cars sampled	Moisture in car samples (average of percentages)	Moisture in face samples (per cent)	Variation from mine moisture (per cent)
1	Christian.....	Sept., Oct., Nov., 1907...........	17	12.67	15.01 Oct., 1908	—2.34
2	Christian...	Dec., Jan., Feb., 1907-1908......	24	13.67	....	—1.34
3	Christian....	March, April, May, 1908......	19	13.89	....	—1.12
4	Christian.....	June, July, Aug., 1908...........	9	14.40	....	— .61
		Average 12 months........	......	13.58	....	—1.43
5	Vermilion...	Sept., Oct., Nov., 1908...........	19	13.71	12.89 (Av. of seven[2])	+ .82
6	Vermilion...	Dec., Jan., Feb., 1908-1909......	19	13.26	....	+ .37
7	Vermilion....	March, April, May, 1909.....	17	13.37	....	+ .48
8	Vermilion...	June, July, Aug., 1909...........	6	11.44	....	—1.45
9	Vermilion...	Sept., Oct., Nov., 1909...........	17	13.32	....	+ .43
		Average 15 months........	......	13.21	....	+ .32

[2] Note—There have been taken in the Danville district from the one mine seven face samples as follows:

13.14 Sept., 1908.
12.76 March, 1912.
12.20
12.70
13.53
13.27
12.67

Av. 12.89

TABLE 6.—*Moisture values in commercial samples at point of delivery compared with coal-bed moisture*—Concluded.
(All samples made on screenings.)

Table No.	County	Dates covered by shipments	No. cars sampled.	Moisture in car samples (average of percentages)	Moisture in face samples (per cent)	Variation from mine moisture (per cent)
10	Vermilion.....	Dec., Jan., Feb., 1909-1910......	28	12.04	....	— .85
11	Vermilion....	March, April, May, 1910.....	12	12.24	....	— .65
12	Vermilion.....	June, July, Aug., 1910...........	4	12.84	....	— .05
		Average 9 months........	.....	12.17	....	— .72
13	Vermilion.....	Dec., Jan., Feb., 1910-1911......	31	12.69	....	— .20
14	Vermilion.....	March, April, May, 1911.....	20	12.20	....	— .69
15	Vermilion.....	June, July, Aug., 1911...........	4	13.03	....	+ .14
16	Vermilion.....	Sept., Oct., Nov., 1911...........	23	13.42	....	+ .53
		Average 12 months........	.....	12.79	....	— .10
17	Vermilion.....	Dec., Jan., Feb., 1911-1912......	35	13.24	12.89 Av. of seven	+ .35
18	Vermilion.....	March, April, May, 1912.....	18	13.99	....	+1.10
19	Vermilion.....	June, July, Aug., 1912...........	9	11.70	....	—1.19
20	Vermilion.....	Sept., Oct., Nov., 1912...........	11	13.80	....	+ .91
21	Vermilion.....	December, 1912..	......	12.76	....	— .13
		Average 12 months..............		13.80	....	+.91

USE OF THE COAL-BED MOISTURE CONTENT AS A BASIS.

From the data presented it seems evident that the controlling factors are weather or season, and distance from the mine to the delivery point. The greater the time between the mining of the coal and its delivery, the greater the variation in moisture from the normal. Furthermore, mine weights are based upon a moisture content which corresponds quite closely to the normal or coal-bed moisture. Although it is true that the moisture content in the mine itself varies to a certain extent at the different working faces, and that there may be further variations due to moisture conditions in the mine and to the extent to which finely divided foreign matter from the floor and roof are allowed to mix with the coal, yet the moisture factor for the regular output of a mine is remarkably uniform.

This uniformity in moisture content indicates the practicability of adopting the normal or coal-bed moisture factor of a given mine as the moisture percentage present in the coal weighed at the mine, on the assumption, of course, that conditions of mining are those which ordinarily attend the handling of coal in Illinois. Indeed, when one examines the variations due to shipping under all sorts of weather conditions, it is seen at once that where settlement is based upon mine weights this method is entirely practicable, and indeed is probably subject to smaller factors of error than the usual sampling methods as carried out at the point of delivery.

Under the system of sampling the coal at the point of delivery loss of moisture is disregarded. The coal is brought to the "air-dry" condition, and the moisture determined on the laboratory sample in the usual manner. The values thus obtained on the "air-dry" sample are calculated to the "dry-coal" basis by dividing each percentage by 1.00 minus the "air-dry" moisture. To derive the values on the wet or mine weight basis, the values for the "dry" basis are multiplied by 1.00 minus the total moisture as established for the coal-bed or normal moisture. The same result in slightly different form may be calculated directly from the "air-dry" to the "wet" coal by multiplying the values obtained from the "air-dry" sample by a factor derived from the expression:

$$\frac{1-W}{1-w}$$

in which W is the total per cent of water assumed to be present in the "wet" coal and w is the per cent of water in the "air-dry" sample.

Of course, if the factor thus derived is applied to the moisture content of the air-dry sample, the resulting value represents the equivalent percentage of that moisture when referred to the "wet" basis. The total moisture of the "wet" coal, therefore, minus the percentage of moisture in the "air-dry" coal gives the moisture loss which would have occurred if a mine sample of the coal had been brought to the same "air-dry" condition and the loss on such air drying obtained by direct weighing. In such a case, however, where a total moisture factor at the mine is recognized, there is no need of determining what would have been the loss on air drying.

RANGE OF VARIATION FOR MOISTURE FACTORS REFERRED TO GEOGRAPHICAL LOCATION.

A study of the tabulated results of coal analysis (Table 9) shows that a certain limited range of variation exists in the vein moisture over certain fairly well defined areas. For example, north and west from Williamson and Jackson Counties the percentage of vein moisture is greatest and averages from 12 to 15 per cent. In that part of coal No. 6 southeast of the Duquoin anticline, the percentage of coal-bed moisture drops appreciably to an average of 7 to 10 per cent, whereas in Saline County a still lower figure is reached for coal No. 5.

ASH.

CAUSES OF VARIATION IN ASH.

The ash in the commercial output of Illinois coals is subject to even greater variations than is the moisture, and, although it is not possible to arrive at so definite a factor for the product of a given mine as can be done for moisture, there is all the more need for acquainting ourselves with certain definite and well-established facts. A few of these facts may be emphasized as follows:

> *1st.* The ash content obtained from selected-lump or hand-picked samples does not necessarily bear any relation to the ash of the average output of the mine.
>
> *2d.* The ash values obtained for coal-bed samples represent approximately the normal ash of the seam. It is most nearly duplicated in the commercial output of the mine by the ash content of the screened lump.
>
> *3d.* The greatest divergence in ash percentages is found in the fine stuff or screenings which often contain double, and sometimes even more than double, the ash of the coal-bed sample. The results seldom fall below 1½ times the normal ash of the bed.

In Table 7 ash values are given for a number of mines in each of which face samples were collected at widely separated points. The variations in the ash content of these samples do not exceed 3.5 per cent in any one mine. This extreme variation probably is due not so much to a variation in the coal as to the impracticability of excluding from each sample exactly the same proportion of the parting, slate, etc. However, the average of the three face samples doubtless constitutes a fair average of the normal or coal-bed ash for any given mine.

TABLE 7.—*Ash in face samples compared with ash in commercial shipping samples taken at the mine.*

County	Coal bed	Ash in face samples "dry coal"	Ash in Commercial samples "Dry coal"				
			Screened lump	Washed nut	Nut 3-inch	Mine run	Screenings
A—Christian	6	7.57	....	....	....	....	19.13
		9.44					
		6.84					
		10.71					
		9.82					
		9.45					
		Av.— 8.97	....	....	....	....	19.13
B—Madison	6	11.71	13.12	14.95	....	....	25.82
		14.00		16.23			
		12.53					
		Av.— 12.75	13.12	15.59	....	....	25.82
C—Madison	6	14.15	....	....	....	15.15	25.72
		12.43					
		12.02					
		Av.— 12.87	....	....	....	15.15	25.72
D—Sangamon	6	10.84	....	....	....	14.71	
		12.42				15.60	
		12.10					
		Av.— 11.79	....	....	....	15.15	
E—Sangamon	6	11.57	....	....	....	14.21	17.96
		12.14	....	....	....	14.81	
		14.13					
		Av.— 12.61	....	....	....	14.52	17.96
F—Sangamon	5	14.73	....	....	17.87	....	17.13
		13.09					
		11.48					
		11.91					
		Av.— 12.80	....	....	17.87	....	17.13

TABLE 7.—*Ash in face samples compared with ash in commercial shipping samples taken at the mine.*—Concluded.

County	Coal bed	Ash in face samples "dry coal"	Ash in Commercial samples "Dry coal"				
			Screened lump	Washed nut	Nut 3-inch	Mine run	Screenings
G—Sangamon	5	9.94					Av. 83 samples
		10.01					
		Av.— 9.98	....	....	....	....	16.02
H—Vermilion	6	11.95	....	....	13.71	....	15.35
		Av.— 11.95	....	....	13.71	....	15.35
I—Williamson	6	9.39	....	....	....	14.06	15.36
		10.48	....	....	....	13.81	
		8.20					
		Av.— 9.36	....	....	....	13.93	15.36
J—Williamson	6	12.46	....	....	....	17.05	17.72
		12.01	....	....	....	16.43	
		12.48					
		Av.— 12.33	....	....	....	16.74	17.72
K—Williamson	6	10.65	....	....	13.98	....	14.13
		Av.—10.65	....	....	13.98	....	14.13

With this value as a basis it is of interest to note that the commercial output will most nearly approach this factor for ash in the screened lump. Probably the next closest agreement is found in the washed nut, the next in the mine-run, and the greatest divergence is naturally in the screenings.

The regular mining processes account for these conditions. The floor underneath the coal bed is composed of earthy matter. With the present-day methods of mining, blasting, and basis of settlement, there is a constant tendency to include this earthy material along with the coal, and since it is in a finely divided form it is not readily seen. In shoveling from the floor, therefore, especially at the clean-up of a room, more or less of this earth or shaly matter goes out as coal. It is obvious, therefore, that the finer material will always be higher in ash, and any other grade will be modified in proportion to the amount of fine stuff present.

CONTROLLING THE QUALITY OF THE OUTPUT.

It is evident from the foregoing that an improvement in quality is possible by exercising care in the various processes of mining and preparation of the output. For example, by careful screening, washing, picking, and other processes, the ash content may be lowered materially, even below the normal factor, just as an increase of dust, dirt, and earthy matter will augment the ash factor. Although it is known that mining methods, such as excessive blasts, basis of settlement, and other factors, directly encourage the mining of this refuse and inert material, it seems evident that the average operator is not aware of the extent to which his output is thus contaminated.

Some misapprehension is evident also with regard to other grades than screenings. Washing of coal, for example, if carefully done, may and should reduce the ash content from these abnormally high figures down to and even below the normal coal-bed ash, but too rapid work or other careless conditions may leave the coal with practically the same ash after passing through the washer as upon entering it. Moreover, the finer the size, the greater the possibility of ash reduction by washing, but there is also greater possibility, and in too many cases the greater probability, that the output from the washer will still retain an unfortunately high ash content.

The ash factor for the run-of-mine output is also subject to wide variations. The first material loaded from a pile just shot down consists chiefly of coarse material and corresponds to a good quality of screened lump. If a number of such mine cars are dumped into the same railway car, such a car when sampled shows a low ash factor, possibly lower than the average normal or vein percentage. On the contrary, if a number of mine cars come to the dump containing a large percentage of clean-up from a room or a number of rooms, such material coming simultaneously into a railway car will cause an ash content for that car to run much above the normal. Doubtless in the long run an average will be maintained which is fairly constant.

NECESSITY FOR MINE OPERATORS TO KNOW THE ASH VALUES OF THEIR COAL.

Every mine operator should come into possession of the data covering these values, and should develop a log of ash values for the various grades of output from his mine, if any attempt is to be made to submit bids in competition where guarantees as to ash values are required. If this knowledge were in hand, serious and very costly errors would be avoided in making contracts. For example, certain of the contracts with the State institutions for the fiscal year 1912-1913 guaranteed to maintain an ash content in screenings, "dry-coal" basis, of 12 and 13 per cent. As a matter of fact, the deliveries frequently ran as high as 20 and 21 per cent and entailed a penalty of 25 to 35 cents per ton. Some of these discrepancies are doubtless due to a lack of information on the part of the operators regarding the possibility of the earthy contamination which usually accompanies screenings.

As a help toward a fuller knowledge of ash values from the various parts of the State, the analytical data presented at the end of this discussion will be found helpful. Over 100 mines have been sampled at their working faces in at least three diffrent points in each mine. Here is a valuable starting point for obtaining the necessary log of ash values for a given mine. Whereas in the tables only the counties are designated for the source of the various samples, the Survey will be glad to furnish the owners of the individual mines the factors for their own face samples, and as soon as further information concerning commercial averages becomes available they will also be willingly placed at the disposal of mine owners.

VOLATILE MATTER, FIXED CARBON, AND SULPHUR.

Volatile matter, fixed carbon, and sulphur, ordinarily do not enter into consideration in making contract specifications. Pound for pound, volatile matter, as a rule is likely to have quite as high or a higher heat value than the fixed carbon. Modern steam-generating appliances should be able to burn one form as efficiently as the other. House heating appliances, however, utilize a relatively low proportion of the volatile material. In the main, this constituent distils off into the air with but poor or partial combustion, and appears at the chimney top in the form of black smoke. For these reasons the higher fixed-carbon coals are better for domestic use than those high in volatile matter. Ash content, density, and sulphur also enter into the account.

Sulphur is present mainly in the form of iron pyrites, and is detrimental to the value of the coal, especially after its first stage of reduction to ferrous sulphide, FeS. This change occurs at relatively low temperatures, from 750° to 900°F, and produces an easily fusible ingredient which promotes slagging and the formation of clinker. Sulphur is not without some virtue as a heat-producing constituent, however, but its value is low, having a little over ⅓ the heat of an equal weight of carbon and about 1/14 the heat of an equal weight of hydrogen. Sulphur may be a constituent of coal varying in amount from one to six per cent, and, because of its chemical form and properties, should be looked upon as an ingredient essentially different from the organic matter or real combustible material. This feature is more fully discussed under the subsequent topic of "unit coal."

Duff or Dust.

Finely divided material above a certain per cent is more detrimental to the effective combustion of coal than is ordinarily realized. When the percentage of material passing through a screen having ¼-inch, round perforations exceeds a certain amount, the difficulties of operation are greatly increased due to the decreased amount of draft, the unevenness of the fire, the honeycombing of flues, the slagging of arches, and other objectionable conditions. A guaranteed maximum of duff should therefore be established. An excess over such maximum percentage should subject the coal to penalty or rejection at the option of the consumer.

Calorific Value.

RELATION BETWEEN QUANTITY OF HEAT CONTAINED AND TRUE VALUE.

Almost without exception the value of a coal is directly proportional to the quantity of heat which it contains Yet occasional installations are known where the type of boiler, the setting, draft, grate area, and other factors, may demand certain physical conditions in the fuel that may take precedence even over the actual heat content. But these cases are the exception rather than the rule. It becomes of prime importance therefore to have an accurate knowledge of the heat possibilities of a given coal, and, indeed, this is made the principal element in contracting and determining the settlement price for coals marketed on the heat-unit basis.

MOST FAVORABLE CONDITIONS FOR DETERMINATION.

The calorific values in British thermal units per pound of coal for all the face samples listed in these tables were determined within ten days at most from the time of collection. There is an appreciable loss in heat values of Illinois coals during the first four to six weeks after breaking out from the seam. Hence, for a fair indication of values it is desirable to obtain the heat values under average conditions of mining and shipment.

Unit Coal.

MEANING AND APPLICATION.

Attention is specifically called to the heat values for the "unit coal," the pure substance free from ash, moisture, sulphur, and other minor impurities. This value like the coal-bed moisture may be regarded as the normal factor for the actual coal and does not vary in a given mine from year to year. If for example, the average unit value for a given mine is 14,350 British thermal units per pound of this material, any sample with whatever content of ash or moisture, when calculated to this "unit-coal" basis, will give the same average value within the range of experimental error, or about 100 units in 14,000, a variation of less than 1 per cent. This value enables us to check the correctness of the various determinations, any one of which if seriously in error would vitiate the result. Conversely, by reversing the calculation we are enabled to obtain a close estimate of the heat value present for any given percentage of ash. This is of special value where it is desired to submit a bid for contracting in which a guaranteed heat value is to be indicated. We have given, therefore, in the tables these "unit-coal" values for each mine sampled. The formula by which this value is derived has already been fully discussed in a former bulletin[3]. Therefore the formula only is repeated here.

$$\text{Unit B. t. u.} = \frac{\text{Dry B. t. u.} - 5000\,S}{1.00 - (1.08A + 55S)}$$

In which A is the weight of ash per gram.
S is the weight of sulphur per gram.

If every mine operator were to obtain as often as possible this "unit" value for his product, he could very shortly derive from an average of his log of values, a basic factor which would be of great advantage to him in submitting propositions for coal supplies. An illustration of such a procedure is given below.

A special survey was recently made of certain mines in the five counties named. The average of the "unit-coal" values for each mine may be taken as a constant for the output of that mine. Attention is called to the close agreement between these values and the averages obtained in the more elaborate survey shown in Table 10.

TABLE 8.—*Average heat value for unit coal*[4] *in British thermal units per pound*

No.	County	Coal bed	Number of samples averaged	Average—B. t. u. "unit coal"
1	Sangamon	5	15	14424
2	Sangamon	6	5	14340
3	Macoupin	6	6	14310
4	Madison	6	18	14350
5	Vermilion	6	19	14597
6	Vermilion	7	9	14730
7	Williamson	6	5	14750

CALCULATION OF COMMERCIAL VALUES.

The use which can be made of these "unit" values such as are shown in this table may be readily understood when it is remembered that each number represents material which is 100 per cent pure and that

[3] Illinois State Geol. Survey, Bull. 16, p. 212, 1909
[4] Pillar and storage coal will have heat units from 1 per cent to 4 per cent below the values here given.

for each per cent of inert matter present, such as water and ash, t is a corresponding decrease in the number of heat units present. T is to say, if a coal has 20 per cent water and ash, then 80 per cen the "unit" value will represent the heat units present per pound of c as delivered. Indeed, it is possible by taking account of certain ref ments, such as correction factors for sulphur and hydration of the sh constituents, to make a calculation which will be of quite suffici accuracy for basing bids and entering into contracts involving a gu antee as to heat values. The method of calculation is exceedingly sim and is based on the following expression:

Let A = weight of ash per pound of coal.

Let S = weight of sulphur per pound of coal.

Then—

"Dry" B.t.u. = "Unit" B.t.u. $\times$ 1.00 — (1.08A + 0.55S) + 5000

To illustrate, take the "unit" value for coal from Vermilion Coun sample No. 6 in Table 8. Suppose we wish to know what heat values ca be guaranteed on deliveries from a mine of this group on the basis th we can furnish material averaging as the "dry coal," 12 per cent as and 3 per cent sulphur, we will have our total non-combustible materia corrected by the above formula as follows:

	Per cent
1.08A	12.96
0.55S	1.65
Total	14.61

100% — 14.61% = 85.39%.

14730 $\times$ 85.39% = 12578.

In this calculation the sulphur has been neglected. It has a small heat value equal to 5000 times the weight of sulphur present or 50 times the percentage number, thus:

50 $\times$ 3 = 150 units to be added to the above value, or

12578
150

12728 B. t.u.[5]

Deliveries from this mine, therefore, having ash, and sulphur as indicated above can be depended upon as carrying 12728 heat units per pound of "dry" coal, and this factor should be accurate within 100 units in 12000 or less than a variation of 1 per cent from values as they would be determined by direct reading from an instrument. Any other set of values for ash and sulphur would similarly admit of ready calculation and should be used as a basis for calculations involving guarantees of deliveries on a heat-unit basis. If the heat units on the "wet" coal basis are desired assuming, for example, a moisture factor of 15 per cent,

[5] Compare sample 4741 Vermilion 6, p. 56.

the above value as derived for "dry" coal should be multiplied by .85, that is, 12728 B.t.u. × .85 = 10818 B.t.u. per pound of the "wet" coal, assuming a moisture factor of 15 per cent as indicated. In this connection attention should be given to the assumed values which it is proposed to maintain for water and ash. Extended calculations are given in Table 12.

ANALYTICAL DATA.

Analyses of Mine Samples.

In Table 10 are given analyses from 345 coal-bed samples which were taken from 100 mines in the State. They are grouped by coal-beds and counties and represent all of the producing areas of the State. Table No. 9 showing counties and district classification is presented for cross reference. (See Plate I).

Table 9.—*Alphabetical arrangement of Counties.*

County	Coal bed	District	County	Coal bed	District
Bond	6	VII	McDonough	1, 2	III
Brown	1, 2	III	McLean	2, 5	I, IV
Bureau	2	I	Menard	5	IV
Calhoun	1, 2	III	Mercer	1, 2	III
Christian	1, 2, 6	III, VII	Montgomery	6	VII
Clinton	6	VII	Moultrie	6	VII
Edgar	6	VIII	Peoria	5	IV
Franklin	6	VI	Perry	6	VI, VII
Fulton	1, 2, 5	III, IV	Putnam	2	I
Gallatin	5, 6	V	Randolph	6	VII
Green	1, 2	III	Rock Island	1, 2	III
Grundy	2	I	St. Clair	6	VII
Hancock	1, 2	III	Saline	5	V
Henry	1, 2, 6	III, VII	Sangamon	5, 6	IV, VII
Jackson	2, 6	II, VI	Schuyler	1, 2	III
Jefferson	6	VI	Scott	1, 2	III
Jersey	1, 2	III	Shelby	6	VII
Knox	1, 2, 5	III, IV	Stark	6	I
LaSalle	2, 5, 7	I	Tazewell	5	IV
Livingston	2, 5, 7	I	Vermilion	6, 7	VIII
Logan	5	IV	Warren	1, 2	III
Macon	5	IV	Washington	6	VII
Macoupin	6	VII	Woodford	2	I
Madison	6	VII	Will	2	I
Marion	6	VII	Williamson	6	VI
Marshall	2, 6	I			

For a given geological bed the counties represented are arranged alphabetically in Table 10. A further grouping is shown by use of the co-operative numbers, these represent samples from the same mine. Two sets of values are given for each sample—one showing the normal or coal-bed moisture, and the other calculated to the "dry-coal" or moisture-free basis. There is also given the value for the "unit-coal" in British thermal units as derived by means of the formula already presented on page 42.

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output*[a]*)*

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
					Coal No. 1.							
5229	21	7/12	Christian	1	11.27	38.68	40.55	9.50	2.07	.33	11445	.....
					Dry	43.59	45.70	10.71	2.33	.37	12898	14066
5230	21	7/12	Christian	1	11.52	38.78	41.01	8.69	2.42	.97	11648	.....
					Dry	43.83	46.35	9.82	2.73	1.10	13163	14707
5231	21	7/12	Christian	1	11.13	39.21	41.26	8.40	2.56	.61	11715	.....
					Dry	44.12	46.43	9.45	2.88	.69	13183	14779
5338	19	8/12	Mercer	1	13.23	40.29	37.20	9.28	4.37	.41	11104	.....
					Dry	46.43	42.88	10.69	5.04	.47	12797	14641
5339	19	8/12	Mercer	1	15.24	37.66	35.73	11.37	4.80	1.47	10353	.....
					Dry	44.44	42.15	13.41	5.66	1.73	12214	14478
5340	19	8/12	Mercer	1	15.15	39.06	38.48	7.31	3.30	.17	11252	.....
					Dry	44.44	42.15	14.41	5.66	1.73	12214	14478
5363	19	8/12	Mercer	1	14.97	38.27	37.07	9.69	3.75	.33	9637	.....
					Dry	46.03	45.36	8.61	3.89	.19	13260	14760
5364	19	8/12	Mercer	1	14.46	40.42	35.33	9.79	4.23	.69	10780	.....
					Dry	44.99	43.61	11.40	4.95	.43	12749	14712
5365	19	8/12	Mercer	1	14.07	39.95	34.01	11.97	4.55	.78	10525	.....
					Dry	47.24	41.32	11.44	4.94	.59	12603	14551
5359	18	8/12	Mercer	1	14.58	39.49	36.82	9.11	5.60	.15	10894	.....
					Dry	46.49	39.59	13.92	5.29	.91	12247	14604
5360	18	8/12	Mercer	1	15.07	38.14	37.44	9.35	4.85	.34	10790	.....
					Dry	46.23	43.09	10.68	6.56	.18	12754	14642
5361	18	8/12	Mercer	1	14.10	39.60	36.73	9.57	3.92	.23	10956	.....
					Dry	44.91	44.01	11.02	5.71	.38	12705	14618
5371	17	8/12	Mercer	1	17.75	39.50	34.61	8.14	5.53	.86	10435	.....
					Dry	48.03	42.08	9.89	6.72	1.05	12687	14373
5372	17	8/12	Mercer	1	17.50	38.78	33.66	10.06	4.51	.29	10238	.....
					Dry	47.00	40.80	12.20	5.46	.35	12409	14372
					Coal No. 2.							
5324	10	8/12	Bureau	2	16.65	36.66	38.58	8.11	3.40	.67	10740	14533
					Dry	43.99	46.29	9.72	4.07	.80	12884	.....
5325	10	8/12	Bureau	2	15.08	40.12	36.35	8.45	3.68	.91	10831	14431
					Dry	47.25	42.80	9.95	4.33	1.07	12754	.....
5326	10	8/12	Bureau	2	16.83	36.54	39.19	7.44	2.64	.89	10788	14463
					Dry	43.93	47.12	8.95	3.17	1.07	12970	.....
5312	10	8/12	Bureau	2	14.88	38.69	37.25	9.08	3.83	1.07	10685	.....
					Dry	45.45	43.76	10.79	4.50	1.25	12553	14357
5313	10	8/12	Bureau	2	17.43	38.07	39.44	5.06	2.68	.52	11070	.....
					Dry	46.10	47.76	6.14	3.25	.63	13407	14462
5314	10	8/12	Bureau	2	16.07	39.68	38.36	5.89	2.96	.57	11216	.....
					Dry	47.28	45.71	7.01	3.53	.63	13363	14571
5348	8	8/12	Bureau	2	15.19	39.67	38.69	6.45	2.20	.99	11206	.....
					Dry	46.78	45.60	7.62	2.62	1.17	13213	14480

[a] Republished from Bulletin 3, Illinois Coal Mining Investigations, Cooperative Agreement.

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5349	8	8/12	Bureau	2	17.34 Dry	37.12 44.90	39.28 47.52	6.26 7.58	2.80 3.38	.49 .59	11006 13314	 14612
5350	8	8/12	Bureau	2	16.97 Dry	38.66 46.56	34.83 41.95	9.54 11.49	2.25 2.71	2.29 2.91	10397 12522	 14386
5205	21	7/12	Christian	2	12.07 Dry	39.36 44.77	41.91 47.66	6.66 7.57	3.74 4.26	.07 .09	11776 13393	 14730
5206	21	7/12	Christian	2	12.53 Dry	38.00 44.12	40.62 46.44	8.25 9.44	3.67 4.22	.31 .35	11389 13020	 14641
5207	21	7/12	Christian	2	14.30 Dry	39.54 46.14	40.30 47.02	5.86 6.84	2.00 2.33	.24 .28	11609 13544	 14702
5367	6	8/12	Grundy	2	19.97 Dry	38.16 47.68	37.45 46.79	4.42 5.53	1.82 2.27	.65 .79	10936 13664	 14003
5368	6	8/12	Grundy	2	18.95 Dry	37.60 46.39	38.23 47.16	5.22 6.45	2.46 3.04	.64 .79	10787 13309	 14400
5369	6	8/12	Grundy	2	19.06 Dry	37.01 46.06	38.16 47.50	5.17 6.44	2.03 2.53	.83 1.03	10734 13360	 14337
5373	5	8/12	Grundy	2	17.29 Dry	38.61 46.68	36.69 44.36	7.41 8.96	2.87 3.47	1.44 1.74	10708 12947	 14447
5374	5	8/12	Grundy	2	13.73 Dry	39.87 46.22	42.19 48.90	4.21 4.88	2.04 2.37	1.47 1.71	11787 13662	 14466
5377	5	8/12	Grundy	2	17.01 Dry	39.48 47.57	36.74 44.27	6.77 8.16	3.32 4.00	1.05 1.27	10834 13055	 14446
5375	7	8/12	Grundy	2	16.84 Dry	38.37 46.13	41.19 49.53	3.60 4.34	1.74 2.09	.04 .05	11508 13838	 14583
5376	7	8/12	Grundy	2	15.81 Dry	39.28 45.48	39.77 47.24	6.13 7.28	2.30 2.73	.24 .28	11212 13318	 14545
5378	7	8/12	Grundy	2	16.23 Dry	38.71 46.22	40.61 48.47	4.45 5.31	2.47 2.94	.32 .38	11461 13683	 14610
5225	14	7/12	Jackson	2	7.72 Dry	35.09 38.02	48.56 52.62	8.63 9.36	2.01 2.18	.29 .31	12248 13272	 14830
5226	14	7/12	Jackson	2	8.77 Dry	32.78 35.93	50.58 55.44	7.87 8.63	2.00 2.19	.02 .03	12253 13430	 14885
5228	14	7/12	Jackson	2	9.18 Dry	34.70 38.20	51.58 56.80	4.54 5.00	.60 .66	.05 .06	12752 14040	 14867
5248	13	7/12	Jackson	2	9.88 Dry	33.23 36.87	52.43 58.18	4.46 4.95	.70 .77	.33 .36	12709 14103	 14926
5249	13	7/12	Jackson	2	10.91 Dry	33.51 37.61	51.20 57.47	4.38 4.92	1.14 1.28	.20 .23	12503 14034	 14863
5250	13	7/12	Jackson	2	9.76 Dry	33.45 37.06	52.07 57.71	4.72 5.23	1.08 1.20	.51 .56	12629 13996	 14874
5351	12	7/12	Jackson	2	9.51 Dry	33.13 36.62	52.12 57.59	5.24 5.79	.66 .73	.94 1.03	12500 13814	 14758
5252	12	7/12	Jackson	2	9.37 Dry	33.39 36.48	49.29 54.38	7.95 8.78	2.11 2.32	.94 1.03	11972 13208	 14671
5253	12	7/12	Jackson	2	9.99 Dry	32.51 36.12	51.88 57.63	5.62 6.25	.62 .69	.20 .22	12308 13673	 14686

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5496	16	8/12	Jackson	2	9.25	34.67	50.53	5.55	1.41	.13	12528	.....
					Dry	38.20	55.68	6.12	1.56	.14	13804	14834
5497	16	8/12	Jackson	2	9.56	34.52	50.47	5.45	1.32	.27	12483	.....
					Dry	38.16	55.83	6.01	1.46	.30	13781	14811
5498	16	8/12	Jackson	2	9.20	34.48	50.54	5.78	1.44	.19	12481	.....
					Dry	37.97	55.66	6.37	1.59	.21	13746	14814
5286	15	8/12	Jackson	2	8.32	35.28	51.10	5.30	1.39	.19	12671	.....
					Dry	38.49	55.74	5.77	1.53	.21	13822	14791
5287	15	8/12	Jackson	2	8.86	35.00	49.74	6.40	1.69	.07	12436	.....
					Dry	38.40	54.57	7.03	1.85	.08	13645	14830
5288	15	8/12	Jackson	2	8.91	34.03	53.17	3.89	1.15	.07	12844	.....
					Dry	37.36	58.37	4.27	1.26	.08	14101	14823
5388	2	8/12	LaSalle	2	14.22	39.49	36.94	9.35	4.46	.80	10887	.....
					Dry	46.03	43.06	10.91	5.20	.93	12691	14562
5389	2	8/12	LaSalle	2	15.16	40.13	38.10	6.61	2.99	.64	11147	.....
					Dry	47.32	44.88	7.80	3.51	.70	13138	14458
5390	2	8/12	LaSalle	2	14.43	40.01	35.89	9.67	4.47	1.03	10678	.....
					Dry	46.75	41.94	11.31	5.23	1.21	12476	14404
5357	4	....	Marshall	2	16.46	38.48	38.27	6.79	2.91	.28	11162	14764
					Dry	46.06	45.80	8.14	3.48	.34	13360	.....
5356	4	....	Marshall	2	16.79	36.81	40.34	6.06	2.59	.41	11130	14620
					Dry	44.23	48.49	7.28	3.11	.49	13375	.....
5358	4	....	Marshall	2	17.54	37.42	40.11	4.93	2.19	.42	11273	14703
					Dry	45.37	48.63	6.00	2.56	.50	13669	.....
5412	11	8/12	Marshall	2	12.92	41.69	37.60	7.78	2.38	.64	11597	.....
					Dry	47.87	43.19	8.94	2.73	.73	13319	14836
5413	11	8/12	Marshall	2	13.10	38.73	39.64	8.53	3.47	.65	11414	.....
					Dry	44.56	45.61	9.83	3.99	.75	13134	14832
5414	11	8/12	Marshall	2	13.82	41.34	35.88	8.96	3.28	.50	11206	.....
					Dry	47.97	41.64	10.39	3.81	.59	13106	14901
5232	22	7/12	McDonough	2	19.35	31.70	40.61	8.34	2.31	.37	10392	.....
					Dry	39.35	50.40	10.35	2.87	.46	12898	14605
5233	22	7/12	McDonough	2	16.46	33.94	42.46	7.14	1.71	.11	11064	.....
					Dry	40.63	50.83	8.54	2.04	.14	13246	14660
5234	22	7/12	McDonough	2	16.39	34.26	41.36	7.99	2.04	.33	10977	.....
					Dry	40.97	49.47	9.56	2.44	.40	13130	14725
5426	100	8/12	McLean	2	10.13	45.00	35.92	8.95	3.27	.74	11710	14723
					Dry	50.07	39.97	9.96	3.59	.82	13029	.....
5427	100	8/12	McLean	2	11.34	40.05	39.18	9.43	3.18	.90	11394	.....
					Dry	45.17	44.19	10.64	3.58	1.01	12851	14643
5428	100	8/12	McLean	2	10.61	41.87	35.94	11.58	3.79	.92	11225	.....
					Dry	46.84	40.21	12.95	4.24	1.03	12557	14752
5429	100	8/12	McLean	2	12.31	42.17	38.03	7.49	2.69	.94	11636	.....
					Dry	48.09	43.37	8.54	3.07	1.07	13270	14722
5430	100	8/12	McLean	2	12.00	42.00	37.96	8.04	2.37	1.23	11634	.....
					Dry	47.73	43.14	9.13	2.70	1.40	13220	14759

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)*—Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5433	100	8/12	McLean	2	11.27	42.17	39.27	7.29	2.91	1.12	11784	.....
					Dry	47.53	44.25	8.22	3.28	1.26	13279	14684
				Coal No. 5.								
5283	31	8/12	Fulton	5	15.18	37.17	35.17	12.48	3.45	1.70	10201	.....
					Dry	43.82	41.45	14.73	4.07	2.00	12026	14441
5284	31	8/12	Fulton	5	16.94	35.68	37.15	10.23	2.98	1.31	10314	.....
					Dry	42.95	44.73	12.32	3.59	1.57	12418	14446
5285	31	8/12	Fulton	5	18.42	34.98	37.66	8.94	2.33	.86	10270	.....
					Dry	42.88	46.15	10.97	2.85	1.06	12587	14371
5296	31	8/12	Fulton	5	16.82	37.28	33.45	12.45	2.84	1.69	10580	.....
					Dry	44.81	40.23	14.96	3.42	2.02	12038	14479
5298	31	8/12	Fulton	5	16.52	37.17	36.54	9.77	3.91	.81	10394	.....
					Dry	44.52	43.78	11.70	4.69	.97	12451	14409
5341	31	8/12	Fulton	5	17.37	35.71	37.86	9.06	2.34	1.14	10420	.....
					Dry	43.22	45.82	10.96	2.83	1.38	12610	14398
5293	29	8/12	Fulton	5	17.13	36.23	34.44	12.20	3.03	1.79	9846	.....
					Dry	43.72	41.55	14.73	3.66	2.16	11882	14252
5297	29	8/12	Fulton	5	16.59	35.98	37.20	10.23	4.07	1.77	10271	.....
					Dry	43.14	44.61	12.25	4.88	2.12	12314	14354
5300	29	8/12	Fulton	5	15.41	35.67	39.04	9.88	3.31	.52	10579	.....
					Dry	42.16	46.15	11.69	3.92	.61	12505	14443
5292	28	8/12	Fulton	5	17.39	37.00	35.69	9.92	2.74	1.14	10273	.....
					Dry	44.79	43.20	12.01	3.28	1.36	12435	14416
5295	28	8/12	Fulton	5	16.33	36.27	36.58	10.82	3.40	1.94	10246	.....
					Dry	43.34	43.72	12.94	4.06	2.32	12247	14371
5299	28	8/12	Fulton	5	16.33	36.75	38.02	8.90	2.59	1.02	10604	.....
					Dry	43.92	45.44	10.64	3.10	1.22	12674	14421
5342	32	8/12	Fulton	5	13.66	38.46	37.06	10.82	3.64	1.26	10689	.....
					Dry	44.54	42.92	12.54	4.22	1.46	12379	14462
5343	32	8/12	Fulton	5	14.53	37.46	38.35	9.66	3.18	1.60	10804	.....
					Dry	43.83	44.87	11.30	3.72	1.87	12641	14525
5344	32	8/12	Fulton	5	15.80	35.84	37.67	10.69	3.00	1.79	10460	.....
					Dry	42.56	44.74	12.70	3.57	2.12	12423	14520
5345	30	8/12	Fulton	5	16.36	33.91	38.19	11.54	2.93	1.27	10186	.....
					Dry	40.54	45.66	13.80	3.50	1.51	12179	14431
5346	30	8/12	Fulton	5	16.33	35.50	37.01	11.16	2.89	1.84	10220	.....
					Dry	42.42	44.23	13.35	3.45	2.20	12213	14389
5347	30	8/12	Fulton	5	15.85	36.12	38.12	9.91	3.36	1.47	10494	.....
					Dry	42.92	45.30	11.78	4.00	1.75	12471	14386
5025	47	6/12	Gallatin	5	5.37	36.54	45.10	12.99	3.99	1.38	11883	.....
					Dry	38.62	47.65	13.73	4.22	1.45	12558	14900
5029	47	6/12	Gallatin	5	5.57	35.49	48.53	10.41	3.12	.78	12338	.....
					Dry	37.59	51.39	11.02	3.31	.83	13066	14953
5032	47	6/12	Gallatin	5	6.21	35.29	46.49	12.02	3.30	.87	11938	.....
					Dry	37.61	49.57	12.82	3.52	.93	12728	14903

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5492	..[7]	8/12	Gallatin	5	4.20	34.41	52.63	8.76	2.85	.01	12997	.....
					Dry	35.92	54.92	9.16	2.97	.01	13566	15164
5493	...	8/12	Gallatin	5	4.07	33.99	52.96	8.98	3.61	.03	12975	.....
					Dry	35.43	55.21	9.36	3.76	.03	13526	15186
5512	...	8/12	Gallatin	5	3.68	37.82	48.18	10.32	4.55	.04	12818	.....
					Dry	39.26	50.02	10.72	4.73	.04	13307	15078
5521	...	8/12	Gallatin	5	3.94	38.13	45.95	11.98	3.53	.03	12449	.....
					Dry	39.70	47.82	12.48	3.67	.03	12958	15117
5522	...	8/12	Gallatin	..[8]	7.15	34.34	53.32	5.19	.84	.03	13035	.....
					Dry	36.99	57.42	5.59	.90	.03	14038	14970
5523	...	8/12	Gallatin	..	4.73	33.91	48.65	11.71	4.78	.04	12429	.....
					Dry	35.59	52.12	12.29	5.02	.04	13045	15240
5530	...	8/12	Gallatin	..	4.03	33.71	51.84	10.41	4.19	.02	12783	.....
					Dry	35.13	54.01	10.86	4.37	.02	13319	15256
5391	..[9]	8/12	LaSalle	5	15.52	41.56	32.57	10.35	4.08	.27	10425	.....
					Dry	49.18	38.55	12.27	4.83	.34	12400	14384
5392	..[9]	8/12	LaSalle	5	14.13	39.42	35.96	10.49	3.22	.96	10636	.....
					Dry	45.90	41.89	12.21	3.75	1.12	12387	14393
5393	..[9]	8/12	LaSalle	5	14.64	43.01	34.25	8.10	2.83	.56	10961	.....
					Dry	50.38	40.12	9.50	3.32	.66	12841	14415
5263	33	8/12	Logan	5	14.64	37.87	35.56	11.93	3.60	1.10	10400	.....
					Dry	44.36	41.66	13.98	4.22	1.28	12183	14497
5264	33	8/12	Logan	5	13.98	36.86	37.98	11.18	3.14	1.43	10549	.....
					Dry	42.84	44.16	13.00	3.65	1.67	12264	14391
5265	33	8/12	Logan	5	13.99	36.85	38.17	10.99	3.26	1.32	10519	.....
					Dry	42.85	44.37	12.78	3.79	1.53	12230	14313
5200	42	7/12	Macon	5	13.52	36.72	39.66	10.10	4.23	.09	10646	.....
					Dry	42.46	45.86	11.68	4.95	.11	12443	14405
5201	42	7/12	Macon	5	13.62	37.72	40.34	8.32	3.39	.00	11046	.....
					Dry	43.68	46.70	9.62	3.93	.00	12788	14403
5202	42	7/12	Macon	5	14.36	38.06	39.35	9.33	3.87	.19	10963	.....
					Dry	43.88	45.37	10.75	4.46	.22	12638	14447
5244	41	7/12	Macon	5	14.76	35.46	38.08	11.70	3.24	.90	10390	.....
					Dry	41.60	44.67	13.73	3.81	1.06	12189	14443
5245	41	7/12	Macon	5	14.54	36.33	38.01	11.12	3.47	.68	10465	.....
					Dry	42.51	44.47	13.01	4.06	.79	12244	14385
5346	41	7/12	Macon	5	14.14	36.21	38.07	11.58	3.24	1.12	10493	.....
					Dry	42.18	44.34	13.48	3.77	1.31	12210	14433
5190	34	8/12	Menard	5	16.29	36.66	38.73	8.32	3.65	.59	10747	.....
					Dry	43.80	46.26	9.94	4.36	.71	12838	14528
5191	34	7/12	Menard	5	15.44	36.38	39.71	8.47	3.34	.26	10841	.....
					Dry	43.03	46.96	10.01	3.95	.31	12820	14505

[7] This and six following analyses are from country banks not in the orignal list of 100 mines.
[8] This and the two following samples are from the "Ice House" coal of Kentucky reports.
[9] From a mine not in the original list of 100.

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —**Continued.**

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5192	34	7/12	Menard	5	20.27	34.58	37.43	7.72	3.31	.63	9919	.....
					Dry	43.37	46.94	9.69	4.16	.79	12441	14402
5431	100	8/12	McLean	5	12.88	38.84	35.80	12.48	3.60	1.17	10601	.....
					Dry	44.58	41.09	14.33	4.14	1.35	12168	14544
5432	100	8/12	McLean	5	13.34	38.39	36.72	11.55	3.59	1.31	10743	.....
					Dry	44.30	42.37	13.33	4.14	1.51	12397	14629
5434	100	8/12	McLean	5	13.73	36.79	36.14	13.34	3.99	1.19	10399	.....
					Dry	42.64	41.89	15.47	4.62	1.30	12054	14639
5303	26	8/12	Peoria	5	16.00	36.06	37.54	10.40	2.90	1.27	10515	.....
					Dry	42.93	44.69	12.38	3.46	1.51	12518	14773
5304	26	8/12	Peoria	5	14.23	37.41	37.36	11.00	3.14	2.17	10573	.....
					Dry	43.62	43.56	12.82	3.66	2.53	12327	14433
5305	26	8/12	Peoria	5	14.76	35.95	35.34	13.95	3.19	2.00	10173	.....
					Dry	42.18	41.46	16.36	3.74	2.34	11935	14636
4985	43	6/12	Saline	5	6.34	37.72	48.20	7.74	2.03	.61	12620	.....
					Dry	40.27	51.46	8.27	2.16	.65	13474	14869
4986	43	6/12	Saline	5	6.40	37.11	49.59	6.90	2.27	.40	12678	.....
					Dry	39.65	52.97	7.38	2.43	.43	13546	14800
4987	43	6/12	Saline	5	8.85	32.53	51.52	7.10	.92	.66	12321	.....
					Dry	35.65	56.57	7.78	1.00	.72	13502	14774
4989	43	6/12	Saline	5	6.80	35.06	50.39	7.75	2.30	.03	12514	.....
					Dry	37.61	54.07	8.32	2.46	.03	13428	14853
4990	43	6/12	Saline	5	6.02	38.23	47.53	8.22	2.67	.45	12538	.....
					Dry	40.68	50.58	8.74	2.84	.48	13341	14831
4992	43	6/12	Saline	5	7.39	35.38	50.73	6.50	2.15	.01	12642	.....
					Dry	38.20	54.78	7.02	2.32	.01	13650	14848
4991	44	6/12	Saline	5	6.49	35.85	50.46	7.20	2.82	.01	12634	.....
					Dry	38.34	53.97	7.69	3.02	.01	13511	14841
4993	44	6/12	Saline	5	6.71	35.68	49.64	7.97	2.69	.00	12482	.....
					Dry	38.24	53.21	8.55	2.88	.00	13379	14839
4994	44	6/12	Saline	5	6.90	34.42	48.55	10.13	2.16	.03	12088	.....
					Dry	36.97	52.16	10.87	2.32	.03	12984	14793
4997	45	6/12	Saline	5	6.71	35.59	49.98	7.72	2.38	.14	12092	.....
					Dry	38.14	53.59	8.27	2.55	.16	13332	14725
4999	45	6/12	Saline	5	7.45	34.18	49.88	8.49	2.78	.01	12336	.....
					Dry	36.94	53.90	9.16	3.01	.01	13329	14901
5001	45	6/12	Saline	5	6.94	34.56	50.93	7.57	2.30	.16	12485	.....
					Dry	37.14	54.72	8.14	2.46	.18	13415	14792
4995	48	6/12	Saline	5	7.57	34.30	48.30	9.77	2.42	1.75	11956	.....
					Dry	37.18	52.25	10.57	2.62	1.89	12934	14692
5002	48	6/12	Saline	5	7.45	33.71	51.27	7.57	2.63	.31	12400	.....
					Dry	36.42	55.40	8.18	2.84	.35	13398	14794
5010	48	6/12	Saline	5	7.99	33.63	51.20	7.18	2.61	.05	12346	.....
					Dry	36.55	55.65	7.80	2.84	.05	13419	14732
5012	49	6/12	Saline	5	5.19	38.37	45.92	10.52	4.06	.46	12200	.....
					Dry	40.47	48.43	11.10	4.28	.49	12932	14847

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO_2	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5015	49	6/12	Saline	5	5.52	36.89	45.89	11.70	4.97	.72	11962	.....
					Dry	39.04	48.58	12.38	5.26	.76	12662	14809
5016	49	6/12	Saline	5	4.90	38.93	45.90	10.27	4.77	.47	12355	.....
					Dry	40.94	48.26	10.80	5.01	.49	12991	14815
5019	46	6/12	Saline	5	8.08	35.26	48.25	8.41	2.00	.38	12192	.....
					Dry	38.35	52.50	9.15	2.83	.41	13263	14818
5020	46	6/12	Saline	5	7.70	35.48	48.66	8.16	2.52	.32	12304	.....
					Dry	38.44	52.72	8.84	2.74	.36	13331	14833
5021	46	6/12	Saline	5	8.25	34.98	47.73	9.04	2.40	.85	11964	.....
					Dry	38.12	52.03	9.85	2.61	.92	13040	14684
5022	46	6/12	Saline	5	7.72	34.09	49.22	8.97	3.31	.23	12050	.....
					Dry	36.94	53.34	9.72	3.58	.25	13057	14716
5023	46	6/12	Saline	5	8.14	34.60	48.10	9.16	2.42	.74	11989	.....
					Dry	37.66	52.36	9.98	2.64	.80	13051	14717
5024	46	6/12	Saline	5	7.85	33.72	49.30	9.13	3.48	.24	11971	.....
					Dry	36.59	53.50	9.91	3.78	.26	12990	14676
5118	36	7/12	Sangamon	5	16.05	35.82	37.14	10.99	3.55	.67	10330	.....
					Dry	42.66	44.25	13.09	4.22	.80	12306	14476
5119	36	7/12	Sangamon	5	15.53	36.36	38.05	10.06	3.86	.55	10522	.....
					Dry	43.04	45.05	11.91	4.57	.66	12457	14450
5120	36	7/12	Sangamon	5	14.45	37.46	38.27	9.82	3.59	.55	10704	.....
					Dry	43.79	44.73	11.48	4.19	.65	12512	14423
5128	37	7/12	Sangamon	5	14.08	37.38	37.56	10.98	3.97	.38	9471	.....
					Dry	43.51	43.71	12.78	5.17	.49	12337	14492
5129	37	7/12	Sangamon	5	13.86	37.11	39.05	9.98	2.57	.52	10726	.....
					Dry	43.08	45.34	11.58	4.07	.61	12451	14365
5166	39	7/12	Sangamon	5	13.38	37.20	36.40	13.01	4.78	.96	10338	.....
					Dry	42.95	42.03	15.02	5.52	1.10	11934	14439
5167	39	7/12	Sangamon	5	13.35	36.64	37.12	12.89	4.80	.84	10348	.....
					Dry	42.27	42.85	14.88	5.53	.97	11942	14423
5168	39	7/12	Sangamon	5	13.19	38.44	36.47	11.90	4.61	1.05	10513	.....
					Dry	44.28	42.00	13.72	5.31	1.20	12110	14397
5187	40	7/12	Sangamon	5	14.82	37.18	38.22	9.78	4.30	.72	10683	.....
					Dry	43.65	44.87	11.48	4.52	.84	12541	14483
5188	40	7/12	Sangamon	5	16.05	35.58	38.04	10.33	4.18	.17	10413	.....
					Dry	42.38	45.32	12.30	4.98	.20	12404	14476
5189	40	7/12	Sangamon	5	14.31	37.31	38.20	10.18	4.21	.90	10655	....
					Dry	43.54	44.58	11.88	4.91	1.05	12434	14251
5196	38	7/12	Sangamon	5	14.25	37.25	37.07	11.43	4.76	.98	10414	.....
					Dry	43.44	43.24	13.32	5.55	1.15	12147	14381
5197	38	7/12	Sangamon	5	14.10	38.74	37.66	9.50	3.86	.75	10790	.....
					Dry	45.09	43.85	11.06	4.50	.87	12564	14415
5198	38	7/12	Sangamon	5	14.44	38.22	37.68	9.66	3.79	.63	10746	.....
					Dry	44.67	44.04	11.29	4.43	.73	12549	14435
5199	38	7/12	Sangamon	5	14.08	38.05	35.30	12.57	5.87	.60	10228	.....
					Dry	44.28	41.09	14.63	6.83	.69	11903	14366

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5289	25	8/12	Sangamon	5	14.23	36.65	37.04	12.08	3.39	1.55	10483	.....
					Dry	42.73	43.18	14.09	3.96	1.81	12220	14553
5290	25	8/12	Sangamon	5	14.54	37.41	37.32	10.73	3.27	1.18	10705	.....
					Dry	43.77	43.67	12.56	3.82	1.38	12526	14625
5291	25	8/12	Sangamon	5	16.00	36.46	37.28	10.26	3.65	.90	10583	.....
					Dry	43.41	44.38	12.21	4.35	1.07	12598	14664
5277	27	7/12	Tazewell	5	14.71	37.46	38.57	10.26	3.51	1.15	10801	.....
					Dry	44.06	44.03	11.91	4.07	1.33	12516	14500
5278	27	7/12	Tazewell	5	13.88	37.58	40.01	8.53	2.55	.95	11076	.....
					Dry	43.64	46.45	9.91	2.96	1.10	12860	14499
5281	27	8/12	Tazewell	5	15.56	37.60	36.70	10.14	3.23	1.50	10552	.....
					Dry	44.53	43.46	12.01	3.83	1.78	12496	14488
				Coal No. 6.								
5052	85	8/12	Clinton	6	12.60	36.78	40.48	10.14	2.88	.77	10827	.....
					Dry	42.07	46.32	11.61	3.29	.88	12388	14269
5053	85	7/12	Clinton	6	12.15	37.74	40.52	9.59	3.51	.29	10949	.....
					Dry	42.96	46.13	10.91	3.99	.33	12464	14256
5054	85	7/12	Clinton	6	12.43	37.23	39.93	10.41	4.19	.38	10730	.....
					Dry	41.28	46.84	11.88	4.79	.44	12253	14211
5073	84	7/12	Clinton	6	13.32	37.43	39.02	10.23	4.06	.69	10726	.....
					Dry	43.18	45.02	11.80	4.68	.80	12374	14336
5074	84	7/12	Clinton	6	12.40	37.94	39.04	10.62	4.24	.58	10796	.....
					Dry	43.32	44.56	12.12	4.84	.69	12323	14380
4785	53	4/12	Franklin	6	10.57	33.37	43.09	12.97	.83	4.38	10714	.....
					Dry	37.30	48.19	14.51	.93	4.89	11980	14236
4786	53	4/12	Franklin	6	10.00	32.80	50.92	6.27	.66	.33	12001	.....
					Dry	36.45	56.59	6.96	.73	.36	13334	14453
4787	53	4/12	Franklin	6	10.15	32.88	50.56	6.41	.59	.22	12000	.....
					Dry	36.59	56.27	7.14	.65	.25	13356	14494
4789	53	4/12	Franklin	6	10.00	32.08	50.93	6.98	.47	.17	11935	.....
					Dry	35.65	56.60	7.75	.52	.20	13261	14492
4791	58	4/12	Franklin	6	8.70	34.62	48.92	7.76	.62	.31	11945	.....
					Dry	37.92	53.59	8.49	.68	.34	13084	14426
4793	58	4/12	Franklin	6	9.04	34.46	48.73	7.77	.68	.23	11946	.....
					Dry	37.88	53.59	8.53	.74	.25	13133	14490
4794	58	4/12	Franklin	6	9.05	34.45	48.75	7.75	.91	.37	11923	.....
					Dry	37.88	53.59	8.53	1.00	.41	13108	14472
4810	52	4/12	Franklin	6	6.96	38.42	44.16	10.46	2.98	.92	11848	.....
					Dry	41.29	47.47	11.24	3.21	.99	12733	14568
4811	52	4/12	Franklin	6	7.34	38.11	44.23	10.32	3.26	1.41	11771	.....
					Dry	41.13	47.73	11.14	3.51	1.53	12703	14561
4812	52	4/12	Franklin	6	6.00	38.55	45.46	9.99	3.16	1.20	11998	.....
					Dry	41.01	48.36	10.63	3.36	1.28	12776	14534
5008	51	6/12	Franklin	6	10.63	33.23	48.79	7.35	1.40	.38	11800	.....
					Dry	37.18	54.59	8.23	1.19	.43	13207	14534

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5009	51	6/12	Franklin	6	9.83	33.91	49.14	7.12	1.13	.18	11942	.....
					Dry	37.62	54.48	7.90	1.25	.20	13245	14522
5011	51	6/12	Franklin	6	10.39	33.13	49.23	7.25	1.37	.06	11920	.....
					Dry	36.97	54.93	8.10	1.53	.06	13303	14629
5208	56	7/12	Franklin	6	6.43	37.62	44.77	11.18	2.64	.64	11834	.....
					Dry	40.20	47.85	11.95	2.82	.68	12646	14620
5209	56	7/12	Franklin	6	10.15	35.55	45.82	8.48	1.41	.80	11691	.....
					Dry	39.56	51.01	9.43	1.57	.89	13011	14539
5211	56	7/12	Franklin	6	7.71	35.75	45.38	11.16	3.50	.89	11644	.....
					Dry	38.74	49.17	12.09	3.79	.96	12616	14644
5222	50	7/12	Franklin	6	9.66	34.55	47.85	7.95	1.04	.31	11916	.....
					Dry	38.24	52.97	8.79	1.15	.34	13190	14613
5223	50	7/12	Franklin	6	9.00	35.10	47.35	8.55	1.08	.40	11973	.....
					Dry	38.58	53.03	9.39	1.19	.44	13159	14684
5224	50	7/12	Franklin	6	9.36	34.86	48.90	6.88	1.01	.43	12122	.....
					Dry	38.46	53.96	7.58	1.12	.48	13373	14603
5507	57	8/12	Franklin	6	9.83	31.82	49.78	8.57	.79	.35	11702	.....
					Dry	35.28	55.22	9.50	.88	.39	12977	14490
5508	57	8/12	Franklin	6	9.44	32.57	50.09	7.90	.67	.29	11914	.....
					Dry	35.97	55.31	8.72	.74	.32	13156	14547
5509	57	8/12	Franklin	6	9.75	32.33	48.77	9.15	1.39	.32	11652	.....
					Dry	35.83	54.03	10.14	1.54	.35	12911	14550
5528	..[10]	8/12	Gallatin	6	10.82	33.83	42.43	12.92	4.93	.42	11263	.....
					Dry	37.94	47.57	14.49	5.53	.47	11609	15193
4773	55	4/12	Jackson	6	10.88	31.71	48.90	8.51	.65	.30	11594	.....
					Dry	35.57	54.88	9.55	.73	.34	13009	14531
4780	55	4/12	Jackson	6	7.17	36.36	45.25	11.22	3.92	.43	11678	.....
					Dry	39.18	48.74	12.08	4.22	.47	12581	14617
4784	55	4/12	Jackson	6	8.82	35.30	44.96	10.92	3.46	.50	11547	.....
					Dry	38.72	49.30	11.98	3.79	.54	12663	14676
5086	66	7/12	Macoupin	6	4.29	39.09	37.21	9.41	4.13	.32	10635	.....
					Dry	45.60	43.42	10.98	4.82	.37	12408	14234
5087	66	7/12	Macoupin	6	13.77	38.69	36.74	10.80	4.37	.62	10493	.....
					Dry	44.86	42.62	12.52	5.07	.71	12169	14236
5088	66	7/12	Macoupin	6	14.73	38.33	37.24	9.70	4.50	.30	10522	.....
					Dry	44.95	43.69	11.36	5.28	.35	12339	14237
5097	69	7/12	Macoupin	6	14.73	36.26	36.11	12.90	4.62	.28	10099	.....
					Dry	42.53	42.34	15.13	5.42	.33	11843	14342
5098	69	7/12	Macoupin	6	13.68	38.02	37.72	10.58	4.43	.21	10618	.....
					Dry	44.05	43.70	12.25	5.12	.25	12300	14346
5099	69	7/12	Macoupin	6	14.19	37.92	37.03	10.86	4.21	.39	10599	.....
					Dry	44.19	43.15	12.66	4.91	.45	12351	14476
5100	67	7/12	Macoupin	6	15.12	38.28	36.55	10.05	3.85	.31	10610	.....
					Dry	45.09	43.06	11.85	4.54	.37	12501	14488

[10] From country bank not included in list of 100 mines.

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5101	67	7/12	Macoupin	6	14.90	37.75	38.43	8.92	3.67	.45	10735	.....
					Dry	44.35	45.16	10.49	4.31	.53	12614	14367
5102	67	7/12	Macoupin	6	14.67	35.49	38.83	11.01	4.15	.22	10433	.....
					Dry	41.59	45.50	12.91	4.86	.26	12227	14370
5112	68	7/12	Macoupin	6	12.11	40.32	39.14	8.43	4.39	.38	11170	.....
					Dry	45.88	44.52	9.60	5.00	.43	12705	14335
5113	68	7/12	Macoupin	6	13.27	38.58	38.15	10.00	4.89	.27	10790	.....
					Dry	44.48	43.99	11.53	5.64	.31	12442	14400
5114	68	7/12	Macoupin	6	13.23	38.85	38.91	9.01	4.39	.28	10935	.....
					Dry	44.77	44.84	10.39	5.06	.32	12601	14359
5067	72	7/12	Madison	6	13.08	38.03	37.07	11.82	5.22	.25	10543	.....
					Dry	43.75	42.65	13.60	6.01	.28	12129	14423
5068	72	7/12	Madison	6	13.53	37.26	40.98	8.23	3.81	.30	10903	.....
					Dry	43.84	45.53	10.63	4.37	.23	12587	14363
5069	72	7/12	Madison	6	14.86	37.32	38.76	9.06	3.73	.20	10717	.....
					Dry	43.84	45.53	10.63	4.37	.23	12587	14363
5070	71	7/12	Madison	6	12.99	37.73	36.89	12.39	4.43	.72	10499	.....
					Dry	43.36	42.40	14.24	5.09	.82	12066	14440
5071	71	7/12	Madison	6	12.14	41.13	38.00	8.73	3.52	.41	11206	.....
					Dry	46.82	43.24	9.94	4.00	.47	12759	14426
5072	71	7/12	Madison	6	12.42	39.82	37.65	10.11	4.35	.72	10909	.....
					Dry	45.46	43.00	11.54	4.96	.80	12456	14398
5075	73	7/12	Madison	6	14.65	39.08	38.03	8.24	3.59	.29	10865	.....
					Dry	45.80	44.55	9.65	4.20	.34	12730	14347
5076	73	7/12	Madison	6	14.31	38.35	38.32	9.02	3.77	.31	10739	.....
					Dry	44.75	44.72	10.53	4.40	.37	12532	14283
5078	73	7/12	Madison	6	15.18	38.40	38.30	8.12	3.94	.23	10751	.....
					Dry	45.27	45.16	9.57	4.64	.27	12673	14284
5515	70	8/12	Madison	6	13.88	37.60	37.74	10.78	4.21	.53	10551	.....
					Dry	43.65	43.82	12.53	4.89	.61	12250	14330
5517	70	8/12	Madison	6	12.44	39.10	38.20	10.26	5.23	.64	10818	.....
					Dry	44.65	43.64	11.71	6.03	.73	12354	14343
5518	70	8/12	Madison	6	12.11	39.32	36.27	12.30	4.92	.47	10615	.....
					Dry	44.74	41.26	14.00	5.60	.53	12076	14421
5030	86	6/12	Marion	6	12.45	37.22	39.81	11.52	3.62	.67	10874	.....
					Dry	42.03	44.96	13.01	4.09	.76	12281	14426
5033	86	6/12	Marion	6	10.24	39.06	39.79	10.91	4.18	.30	11180	.....
					Dry	43.51	44.33	12.16	4.65	.34	12456	14499
5035	86	6/12	Marion	6	10.69	38.76	39.01	11.54	3.98	.51	10963	.....
					Dry	43.41	43.66	12.93	4.47	.57	12275	14418
5039	87	6/12	Marion	6	10.06	37.96	41.09	10.89	3.92	.59	11289	.....
					Dry	42.21	45.69	12.10	4.35	.66	12555	14589
5041	87	6/12	Marion	6	10.35	36.04	42.81	10.80	4.10	.25	11227	.....
					Dry	40.20	47.75	12.05	4.57	.28	12522	14551
5044	87	6/12	Marion	6	10.96	36.54	40.68	11.82	4.00	.43	11002	.....
					Dry	41.04	45.69	13.27	4.52	.48	12364	14583

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5105	76	7/12	Montgomery	6	14.15	36.96	38.19	10.70	3.43	.91	10547	.....
					Dry	43.05	44.48	12.47	4.00	1.06	12285	14329
5106	76	7/12	Montgomery	6	13.83	36.95	39.22	10.00	3.72	.91	10728	.....
					Dry	42.88	45.51	11.61	4.32	1.05	12455	14382
5107	76	7/12	Montgomery	6	13.70	37.25	37.93	11.12	4.39	1.04	10444	.....
					Dry	43.17	43.94	12.89	5.08	1.20	12102	14225
5516	77	8/12	Montgomery	6	14.00	36.88	40.02	9.10	3.84	.48	10761	.....
					Dry	42.88	46.54	10.58	4.47	.57	12511	14268
5254	..[11]	8/12	Moultrie	6	7.07	39.02	43.01	10.90	3.69	.36	11912	.....
					Dry	41.99	46.28	11.73	3.97	.39	12819	14736
5255	...	8/12	Moultrie	6	7.18	38.09	41.38	13.35	5.18	.46	11573	.....
					Dry	41.03	44.59	14.38	5.58	.49	12468	14973
5256	...	8/12	Moultrie	6	6.24	40.34	42.55	10.87	3.18	.89	12149	.....
					Dry	43.03	45.38	11.59	3.39	.95	12957	14937
4756	54	3/12	Perry	6	10.32	34.03	46.19	9.46	1.07	.24	11395	.....
					Dry	37.94	51.51	10.55	1.18	.26	12705	14380
4759	54	3/12	Perry	6	10.41	33.43	45.82	10.34	.88	.23	11486	.....
					Dry	37.32	51.14	11.54	.98	.25	12822	14367
4760	54	3/12	Perry	6	10.22	33.32	47.60	8.86	1.04	.23	11270	.....
					Dry	37.11	53.03	9.86	1.15	.25	12553	14383
4764	54	3/12	Perry	6	9.98	33.71	44.91	11.40	.84	.33	11205	.....
					Dry	37.45	49.88	12.67	.93	.37	12447	14452
4766	54	3/12	Perry	6	9.64	33.49	45.60	11.27	.82	.35	11230	.....
					Dry	37.06	50.47	12.47	.90	.39	12428	14394
4768	54	3/12	Perry	6	10.05	33.24	45.85	10.86	.93	.63	11257	.....
					Dry	36.94	50.98	12.08	1.04	.70	12513	14424
5034	90	6/12	Perry	6	10.60	37.03	42.32	10.05	3.73	.62	11175	.....
					Dry	41.42	47.35	11.23	4.17	.70	12500	14365
5037	90	6/12	Perry	6	11.20	37.29	40.57	10.94	3.20	.34	10911	.....
					Dry	42.00	45.69	12.31	3.60	.39	12287	14288
5038	90	6/12	Perry	6	10.60	35.99	43.05	10.36	4.18	.47	11012	.....
					Dry	40.25	48.16	11.59	4.67	.53	12317	14228
5040	90	6/12	Perry	6	11.60	37.03	42.17	9.20	3.84	.38	11107	.....
					Dry	41.89	47.71	10.40	4.34	.43	12570	14301
5042	90	6/12	Perry	6	10.82	37.83	41.52	9.83	2.98	.76	11210	.....
					Dry	42.42	46.56	11.02	3.34	.85	12570	14380
5043	90	6/12	Perry	6	10.89	36.81	41.23	11.07	3.71	.55	10826	.....
					Dry	41.29	46.27	12.44	4.16	.52	12277	14319
5048	88	7/12	Perry	6	9.37	36.87	41.05	12.71	4.62	.43	10936	.....
					Dry	40.68	45.29	14.02	4.83	.47	12067	14395
5049	88	7/12	Perry	6	9.34	37.97	41.32	11.37	3.16	1.42	11099	.....
					Dry	41.88	45.58	12.54	3.48	1.56	12243	14276
5050	88	7/12	Perry	6	10.11	36.44	41.45	12.00	3.59	.75	10915	.....
					Dry	40.54	40.12	13.34	3.99	.81	12141	14321

[11] This and two following samples are from a mine not included in the list of 100.

Table 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —**Continued.**

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5514	89	8/12	Perry	6	12.43	35.55	42.86	9.16	4.80	.21	11063	.....
					Dry	40.59	48.94	10.47	5.48	.25	12632	14422
5519	89	8/12	Perry	6	12.76	35.18	44.32	7.74	1.66	.15	11357	.....
					Dry	41.79	49.34	8.87	1.90	.17	13018	14458
5520	89	8/12	Perry	6	12.17	36.42	42.41	9.00	1.96	.46	11200	.....
					Dry	41.46	48.28	10.26	2.23	.52	12753	14414
5045	83	8/12	Randolph	6	11.38	36.94	40.25	11.43	4.16	.72	10823	.....
					Dry	41.68	45.41	12.91	4.69	.81	12212	14348
5046	83	8/12	Randolph	6	10.62	38.10	39.12	12.16	4.45	.42	10849	.....
					Dry	42.63	43.77	13.60	4.98	.47	12137	14400
5047	83	8/12	Randolph	6	11.39	36.80	41.04	10.77	4.11	.60	10895	.....
					Dry	41.53	46.32	12.15	4.63	.67	12294	14306
5115	75	8/12	Sangamon	6	14.97	36.90	38.36	9.77	3.53	.59	10598	.....
					Dry	43.39	45.12	11.49	4.16	.67	12466	14361
5116	75	8/12	Sangamon	6	14.51	37.60	39.69	8.20	3.44	.22	10911	.....
					Dry	43.98	46.43	9.59	4.02	.25	12763	14373
5117	75	8/12	Sangamon	6	12.98	38.23	38.92	9.87	4.32	.56	10845	.....
					Dry	43.94	44.72	11.34	4.96	.65	12463	14368
5130	74	7/12	Sangamon	6	15.22	38.23	37.36	9.19	4.38	.38	10579	.....
					Dry	45.09	44.07	10.84	5.17	.45	12478	14301
5131	74	7/12	Sangamon	6	13.10	38.86	37.25	10.79	5.08	.41	10592	.....
					Dry	44.72	42.86	12.42	5.86	.47	12187	14268
5132	74	7/12	Sangamon	6	14.43	38.14	37.07	10.36	4.77	.40	10495	.....
					Dry	44.58	43.32	12.10	5.58	.47	12265	14292
5056	79	7/12	St. Clair	6	10.69	40.16	37.87	11.28	4.55	.58	11063	.....
					Dry	44.97	42.39	12.64	5.10	.65	12387	14522
5058	79	7/12	St. Clair	6	12.12	38.61	40.61	8.66	3.10	.35	11217	.....
					Dry	43.93	46.22	9.85	3.52	.39	12764	14399
5059	79	7/12	St. Clair............	6	11.12	40.54	38.27	10.07	4.18	.32	11145	.....
					Dry	45.61	43.06	11.33	4.70	.36	12540	14483
5055	78	7/12	St. Clair............	6	13.06	38.21	37.36	11.37	3.21	1.17	10741	.....
					Dry	43.95	42.96	13.09	3.70	1.35	12354	14515
5060	78	7/12	St. Clair............	6	11.44	38.73	38.11	11.72	4.26	.56	10841	.....
					Dry	43.73	43.04	13.23	4.81	.64	12242	14447
5061	78	7/12	St. Clair............	6	10.75	39.19	38.88	11.18	3.41	.67	11041	.....
					Dry	43.91	43.56	12.53	3.82	.75	12371	14438
5077	81	7/12	St. Clair............	6	11.35	39.68	38.59	10.38	4.05	.58	11036	.....
					Dry	44.75	43.54	11.71	4.57	.65	12449	14404
5079	81	7/12	St. Clair............	6	10.85	40.75	38.36	10.04	4.09	.58	11192	.....
					Dry	45.71	43.03	11.26	4.58	.65	12554	14445
5080	81	7/12	St. Clair............	6	11.50	40.68	37.91	9.91	3.96	.46	10908	.....
					Dry	45.96	42.84	11.20	4.47	.52	12597	14482
5108	82	7/12	St. Clair............	6	10.99	38.96	58.79	11.26	4.36	.36	11047	.....
					Dry	43.77	43.59	12.64	4.90	.40	12411	14544
5109	82	7/12	St. Clair............	6	13.42	39.23	36.92	10.43	4.92	.26	10753	.....
					Dry	45.31	42.65	12.04	5.69	.31	12419	14474

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.'	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5110	82	7/12	St. Clair............	6	11.40	40.96	36.89	10.75	4.10	.57	11052	.....
					Dry	46.23	41.63	12.14	4.63	.63	12472	14511
5524	80	7/12	St. Clair............	6	10.11	39.72	38.87	11.30	3.69	.78	11051	.....
					Dry	44.19	43.24	12.57	4.10	.86	12294	14361
5525	80	8/12	St. Clair............	6	9.83	39.84	37.97	12.36	4.02	.87	10958	.....
					Dry	44.19	42.11	13.70	4.45	.96	12152	14415
5526	80	8/12	St. Clair............	6	10.19	38.44	40.41	10.96	3.95	.68	11127	.....
					Dry	42.79	45.00	12.21	4.49	.78	12388	14418
4670	93	2/12	Vermilion	6	13.68	36.28	41.37	8.67	2.78	.45	11101	.....
					Dry	42.03	47.92	10.05	3.23	.52	12861	14537
4671	93	2/12	Vermilion	6	15.50	33.32	43.11	8.07	1.86	.46	10976	.....
					Dry	39.43	51.03	9.54	2.20	.62	12989	14558
4674	93	2/12	Vermilion	6	15.69	34.52	42.22	7.57	1.56	.53	11019	.....
					Dry	40.95	50.07	8.98	1.85	.63	13085	14553
4676	93	2/12	Vermilion	6	14.56	35.04	41.82	8.58	2.09	.74	11006	.....
					Dry	41.01	48.95	10.04	2.45	.86	12881	14527
4678	93	2/12	Vermilion	6	16.06	34.67	40.75	8.52	1.79	.90	10810	.....
					Dry	41.32	48.53	10.15	2.14	1.07	12879	14537
4679	93	2/12	Vermilion	6	15.95	34.66	42.06	7.33	1.41	.39	11041	.....
					Dry	41.23	50.05	8.72	1.68	.46	13136	14557
4702	92	3/12	Vermilion	6	15.53	33.60	39.46	11.41	2.32	.98	10404	.....
					Dry	39.78	46.70	13.52	2.75	1.15	12317	14520
4703	92	3/12	Vermilion	6	15.70	32.38	39.80	11.36	2.57	1.06	10392	.....
					Dry	38.81	47.72	13.47	3.04	1.26	12328	14535
4704	92	3/12	Vermilion	6	15.27	33.98	40.88	9.87	2.26	.69	10718	.....
					Dry	40.10	48.24	11.66	2.66	.81	12649	14563
4706	95	3/12	Vermilion	6	11.87	40.37	39.52	8.24	3.07	.74	11416	.....
					Dry	45.80	44.86	9.34	3.48	.84	12953	14525
4707	95	3/12	Vermilion	6	13.14	38.81	38.11	9.94	4.18	.88	10949	.....
					Dry	44.69	43.87	11.44	4.82	1.02	12604	14549
4740	91	6/12	Vermilion	6	13.58	35.20	39.83	11.39	3.19	.83	10821	.....
					Dry	40.73	46.09	13.18	3.69	.96	12521	14733
4741	91	6/12	Vermilion	6	13.63	34.56	41.19	10.62	2.91	.78	10954	.....
					Dry	40.01	47.69	12.30	3.36	.90	12683	14747
4742	91	6/12	Vermilion	6	14.50	35.98	40.49	9.03	2.43	.44	11090	.....
					Dry	42.09	47.35	10.56	2.83	.52	12971	14740
4743	91	6/12	Vermilion	6	14.20	35.79	42.05	7.96	1.83	.34	11295	.....
					Dry	41.71	49.01	9.28	2.13	.39	13165	14703
4744	91	6/12	Vermilion	6	13.99	35.26	42.68	8.07	1.67	.98	11271	.....
					Dry	40.99	49.63	9.38	1.94	1.14	13104	14706
4745	91	6/12	Vermilion	6	14.79	34.44	42.69	8.08	1.72	.98	11053	.....
					Dry	40.42	50.10	9.48	2.02	1.15	12971	14519
4746	91	6/12	Vermilion	6	15.14	33.70	40.19	10.97	2.50	.61	10663	.....
					Dry	39.72	47.34	12.94	2.95	.72	12565	14712
4998	65	6/12	Williamson	6	9.35	32.83	50.07	7.75	1.05	.26	12017	.....
					Dry	36.21	55.24	8.55	1.16	.29	13256	14644

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Continued.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5004	65	6/12	Williamson	6	9.99	33.79	48.56	7.66	.99	.06	11899	.....
					Dry	37.53	53.96	8.51	1.10	.06	13218	14593
5005	65	6/12	Williamson	6	8.58	33.95	48.31	9.16	3.10	.14	11845	.....
					Dry	37.14	52.84	10.02	3.39	.16	12956	14644
4996	60	6/12	Williamson	6	8.32	34.61	47.56	9.51	2.25	.24	11978	.....
					Dry	37.75	51.88	10.37	2.46	.26	13066	14801
5000	60	6/12	Williamson	6	7.53	34.90	47.37	10.20	3.23	.60	11799	.....
					Dry	37.74	51.23	11.03	3.49	.65	12760	14607
5006	60	6/12	Williamson	6	8.81	32.13	51.85	7.21	1.00	.13	11962	.....
					Dry	35.62	56.38	8.00	1.11	.16	13264	14572
5121	61	6/12	Williamson	6	9.44	33.63	49.58	7.35	1.28	.19	12092	.....
					Dry	37.13	54.75	8.12	1.42	.21	13354	14685
5133	61	7/12	Williamson	6	8.99	34.22	49.51	7.28	1.70	.04	12149	.....
					Dry	37.62	54.39	7.99	1.87	.04	13349	14674
5134	61	7/12	Williamson	6	9.38	33.62	50.01	6.99	1.12	.14	12138	.....
					Dry	37.10	55.18	7.72	1.24	.16	13394	14654
5122	59	7/12	Williamson	6	9.79	33.28	48.66	8.27	1.32	.44	11891	.....
					Dry	36.89	53.94	9.17	1.46	.49	13181	14681
5123	59	7/12	Williamson	6	10.67	32.54	47.32	9.47	1.53	.15	11619	.....
					Dry	36.42	52.97	10.61	1.71	.17	13006	14748
5124	59	7/12	Williamson	6	10.96	33.14	45.86	10.04	1.72	.55	11383	.....
					Dry	37.24	51.49	11.27	1.93	.62	12784	14624
5125	62	7/12	Williamson	6	9.97	32.20	49.62	8.21	1.47	.22	11814	.....
					Dry	35.76	55.12	9.12	1.63	.25	13123	14610
5126	62	7/12	Williamson	6	8.37	34.19	50.18	7.26	1.03	.18	12254	.....
					Dry	37.31	54.77	7.92	1.12	.20	13374	14663
5127	62	7/12	Williamson	6	9.06	32.93	49.98	8.03	1.03	.24	12010	.....
					Dry	36.20	54.97	8.83	1.13	.27	13207	14637
5170	64	7/12	Williamson	6	11.51	30.75	49.74	8.00	.84	.32	11554	.....
					Dry	34.76	56.20	9.04	.90	.36	13057	14501
5169	64	7/12	Williamson	6	9.13	32.03	51.06	7.77	1.10	.33	12044	.....
					Dry	35.25	56.20	8.55	1.21	.36	13254	14613
5172	64	7/12	Williamson	6	7.38	35.59	47.56	9.47	.86	.51	12017	.....
					Dry	38.42	51.35	10.23	.93	.55	12974	14617
5180	63	7/12	Williamson	6	10.38	32.76	48.10	8.76	1.50	.16	11735	.....
					Dry	36.56	53.67	9.77	1.67	.18	13072	14672
5181	63	7/12	Williamson	6	8.78	34.25	47.56	9.41	2.49	.53	11885	.....
					Dry	37.54	52.14	10.32	2.73	.58	13029	14758
5182	63	7/12	Williamson	6	9.26	33.36	48.70	8.68	1.83	.39	11955	.....
					Dry	36.76	53.68	9.56	2.01	.43	13176	14761
			Coal No. 7.									
5416	99	8/12	La Salle	7	13.82	41.42	35.90	8.86	3.95	.51	11174	.....
					Dry	48.06	41.67	10.27	4.58	.59	12966	14744
5414	99	8/12	La Salle	7	12.87	42.40	37.35	7.88	3.86	.00	11468	.....
					Dry	48.67	42.86	8.47	4.44	.00	13161	14635

TABLE 10.—*Analyses of mine samples (not exactly indicative of commercial output)* —Concluded.

Lab. No.	Co-Op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free. Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	Unit coal
5417	99	8/12	La Salle	7	13.99	38.81	40.12	7.08	3.23	.00	11401	.....
					Dry	45.12	46.65	8.23	3.76	.00	13255	14675
4711	94	3/12	Vermilion	7	12.20	39.53	38.38	9.89	3.76	.46	11243	.....
					Dry	45.03	43.70	11.27	4.29	.52	12804	14730
4713	94	3/12	Vermilion	7	12.70	39.20	39.24	8.86	2.79	.52	11399	.....
					Dry	44.90	44.95	10.15	3.19	.59	13057	14776
4714	94	3/12	Vermilion	7	12.76	38.84	38.31	10.09	3.91	.61	11106	.....
					Dry	44.53	43.91	11.56	4.48	.70	12788	14773
4716	94	3/12	Vermilion	7	12.67	39.01	37.43	10.89	3.54	.84	11041	.....
					Dry	44.67	42.86	12.47	4.06	.96	12644	14734
4722	94	3/12	Vermilion	7	13.53	37.39	39.57	9.51	3.20	.46	11045	.....
					Dry	43.24	45.76	11.00	3.70	.54	12773	14622
4724	94	3/12	Vermilion	7	13.27	37.25	40.65	8.83	3.27	.38	11209	.....
					Dry	42.95	46.87	10.18	3.77	.44	12925	14650
4727	97	3/12	Vermilion	7	12.92	36.98	38.94	11.16	2.90	.70	10924	.....
					Dry	42.46	44.73	12.81	3.33	.80	12544	14715
4734	97	3/12	Vermilion	7	13.10	38.42	39.14	9.34	2.26	.56	11281	.....
					Dry	44.22	45.03	10.75	2.59	.64	12981	14778
4736	97	3/12	Vermilion	7	13.41	37.33	38.87	10.39	2.54	.46	11065	.....
					Dry	43.11	44.89	12.00	2.93	.53	12778	14787

AVERAGE ANALYSES BY MINES AND BY COUNTIES.

In Table 11, the average of all of the values for each mine is given and these values for each county are assembled for more convenient reference. Further, since as a rule, the variations for "unit" values in a county are slight, the average for the county is calculated from the several mine averages. These values are therefore accurate for the various counties named, though, of course, the range of variation for each mine would be less than for the county as a whole.

By means of the preceding discussion of the meaning and application of these values and the analytical results as given in Tables 8, 10, 11, and 12, both the coal operator who wishes to formulate bids, and the contractor who wishes to meet safely present-day commercial requirements should be able to make practical application of the data. Table 12 especially furnishes calculations for typical samples from the entire area.

TABLE 11.—*Average analytical and heat values for separate mines and by counties—grouped according to districts.*—**Continued.**

DISTRICT NO. 1. BUREAU CO., COAL NO. 2. LONGWALL MINING.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
1	16.19	37.79	38.06	8.00	3.24	.82	10787	14476
	Dry	45.06	45.40	9.54	3.86	.98	12869	
8	16.50	38.48	37.59	7.43	2.40	1.16	10868	14493
	Dry	46.08	45.02	8.90	2.90	1.39	13016	
10	16.13	38.82	38.36	6.69	3.15	.70	10994	14463
	Dry	46.28	45.74	7.98	3.76	.84	13108	
Average	16.27	38.35	38.00	7.38	2.93	.89	10883	14477
	Dry	45.80	45.39	8.81	3.50	1.40	12997	

DISTRICT NO. 1. LA SALLE CO., COAL NO. 2. LONGWALL MINING.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
2	14.60	39.88	36.97	8.55	3.97	.81	10904	14475
	Dry	46.70	43.29	10.01	4.65	.95	12768	
3	15.05	39.76	37.00	8.19	3.30	.59	10899	14454
	Dry	46.80	43.56	9.64	3.88	.69	12830	
9	17.45	38.98	34.52	9.04	3.18	1.49	10391	14403
	Dry	47.22	41.82	10.95	3.85	1.81	12587	
Average	15.70	39.54	36.17	8.59	3.48	.96	10731	14444
	Dry	46.91	42.89	10.20	4.12	1.15	12728	

DISTRICT NO. 1. MARSHALL CO., COAL NO. 2. LONGWALL MINING.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
4	16.93	37.57	39.57	5.93	2.53	.37	11188	14696
	Dry	45.22	47.64	7.14	3.05	.44	13468	
11	13.28	40.58	37.71	8.43	3.04	.60	11435	14896
	Dry	46.80	43.48	9.72	3.51	.69	13186	
Average	15.10	39.06	38.68	7.16	2.79	.48	11315	14796
	Dry	46.01	45.56	8.43	3.28	.56	13327	

DISTRICT NO. 1. GRUNDY CO., COAL NO. 2. LONGWALL MINING.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
5	16.01	39.32	38.51	6.16	2.75	1.32	11104	14463
	Dry	46.83	45.84	7.33	3.28	1.57	13221	
6	19.53	37.59	37.94	4.94	2.01	.70	10818	14447
	Dry	46.71	47.15	6.14	2.61	.87	13444	
7	16.29	38.46	40.53	4.72	2.17	.48	11394	14579
	Dry	45.94	48.42	5.64	2.59	.57	13613	
Average	17.28	38.48	39.02	5.27	2.33	.83	11113	14496
	Dry	46.49	47.14	6.37	2.82	1.00	13426	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —Grouped according to districts.*—**Continued.**

DISTRICT NO. 2. JACKSON CO., COAL NO. 2. ROOM AND PILLAR MINING.

Co-op No.	Moist-ure	Volatile Matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
12	9.62	33.02	51.09	6.27	1.13	.69	12260	14705
	Dry	36.53	56.53	6.94	1.25	.76	13565	
13	10.18	33.40	51.90	4.52	.97	.29	12614	14888
	Dry	37.18	57.79	5.03	1.08	.32	14044	
14	8.56	34.18	50.25	7.01	1.54	.09	12418	14864
	Dry	37.39	54.95	7.66	1.68	.10	13581	
15	8.70	34.77	51.34	5.19	1.42	.09	12651	14815
	Dry	38.08	56.23	5.69	1.55	.12	13856	
16	9.34	34.55	50.52	5.59	1.40	.26	12490	14820
	Dry	38.11	55.72	6.17	1.54	.29	13777	
Aver-age	9.28	33.98	51.02	5.72	1.29	.29	12488	14818
	Dry	37.46	56.24	6.30	1.42	.32	13765	

DISTRICT NO. 3. MERCER CO., COAL NO. 1. ROOM AND PILLAR MINING.

Co-op No.	Moist-ure	Volatile Matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
17	17.63	39.13	34.13	9.11	5.02	.70	10336	14373
	Dry	47.51	41.44	11.05	6.09	.85	12548	
18	14.58	39.07	37.00	9.35	4.79	.21	10880	14640
	Dry	45.74	43.31	10.95	5.61	.25	12737	
19	14.52	39.26	36.32	9.90	4.24	.68	10809	14624
	Dry	45.93	42.49	11.58	4.96	.80	12645	
Aver-age	15.58	39.17	35.80	9.45	4.69	.53	10673	14546
	Dry	46.40	42.41	11.19	5.55	.63	12643	

DISTRICT NO. 3. CHRISTIAN CO., COAL NO. 1. ROOM AND PILLAR MINING.

Co-op No.	Moist-ure	Volatile Matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
21	11.31	38.89	40.94	8.86	2.35	.43	11602	14717
	Dry	43.85	46.16	9.99	2.65	.48	13081	

DISTRICT NO. 4. PEORIA CO., COAL NO. 5. CENTRAL ILLINOIS.

Co-op No.	Moist-ure	Volatile Matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
25	14.92	36.92	37.21	11.02	3.44	1.21	10951	14614
	Dry	43.30	43.74	12.95	4.04	1.42	12448	
26	15.00	36.48	36.75	11.77	3.08	1.80	10421	14614
	Dry	42.91	43.24	13.85	3.62	2.12	12260	
Aver-age	14.96	36.65	36.99	11.40	3.26	1.50	10506	14614
	Dry	43.10	43.49	13.40	3.83	1.77	12354	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —Grouped according to districts.*—Continued.

Co-op No.	Moist-ure	Volatile matter	Fixed carbon	Ash	Sul-phur	CO_2	B. t. u.	"Unit coal"
DISTRICT NO. 4. TAZEWELL CO., COAL NO. 5. CENTRAL ILLINOIS.								
27	14.38	37.74	38.23	9.66	3.10	1.20	10809	14496
	Dry	44.08	44.65	11.28	3.62	1.40	12624	
DISTRICT NO. 4. LOGAN CO., COAL NO. 5. CENTRAL ILLINOIS.								
33	14.20	37.19	37.44	11.37	3.34	1.42	10490	14400
	Dry	43.35	43.40	13.25	3.89	1.66	12226	
DISTRICT NO. 4. FULTON CO., COAL NO. 5. CENTRAL ILLINOIS.								
28	16.68	36.68	36.76	9.88	2.90	1.36	10375	14403
	Dry	44.02	44.12	11.86	3.48	1.63	12452	
29	16.38	35.96	36.88	10.78	3.47	1.02	10230	14349
	Dry	43.01	44.10	12.89	4.15	1.22	12234	
30	16.18	35.17	37.77	10.88	3.06	1.53	10296	14402
	Dry	41.96	45.06	12.98	3.65	1.82	12284	
31	16.88	36.32	36.32	10.48	2.98	1.25	10269	14424
	Dry	43.70	43.70	12.61	3.58	1.50	12355	
32	14.66	37.24	37.71	10.39	3.28	1.54	10651	14502
	Dry	43.64	44.18	12.18	3.84	1.81	12481	
Aver-	16.16	36.27	37.09	10.48	3.14	1.33	10363	14416
age	Dry	43.26	44.24	12.50	3.74	1.59	12361	
DISTRICT NO. 4. MENARD CO., COAL NO. 5. CENTRAL ILLINOIS.								
34	17.33	35.88	38.62	8.17	3.44	.50	10499	14478
	Dry	43.40	46.72	9.88	4.16	.60	12700	
DISTRICT NO. 4. SANGAMON CO., COAL NO. 5. CENTRAL ILLINOIS.								
36	15.34	36.54	37.83	10.29	3.67	.59	10519	14450
	Dry	43.16	44.68	12.16	4.33	.70	12425	
37	13.78	37.82	37.69	10.73	4.11	.47	10625	14396
	Dry	43.86	43.71	12.14	4.77	.55	12323	
38	14.26	38.07	37.48	10.19	4.14	.37	10649	14410
	Dry	44.40	43.71	11.89	4.83	.43	12420	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —grouped according to districts.*—Continued.

DISTRICT NO. 4, SANGAMON CO., COAL NO. 5, CENTRAL ILLINOIS —Concluded.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
39	13.31	37.43	36.66	12.60	4.72	.94	10398	14420
	Dry	43.17	42.29	14.54	5.45	1.09	11995	
40	15.06	36.69	38.15	10.10	4.08	.59	10584	14403
	Dry	43.19	44.92	11.89	4.80	.69	12460	
Average	14.35	37.30	37.57	10.78	4.16	.59	10555	14415
	Dry	43.55	43.86	12.59	4.86	.69	12323	

DISTRICT NO. 4. MACON CO., COAL NO. 5. CENTRAL ILLINOIS.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
41	14.48	36.00	38.05	11.47	3.32	.90	10445	14420
	Dry	42.10	44.49	13.41	3.88	1.05	12214	
42	13.83	37.35	39.62	9.20	3.83	.09	10877	14418
	Dry	43.34	45.98	10.68	4.45	.11	12623	
Average	14.15	36.68	38.83	10.34	3.57	.52	10661	14419
	Dry	42.73	45.23	12.04	4.16	.60	12418	

DISTRICT NO. 5. SALINE CO., COAL NO. 5. SOUTHERN ILLINOIS.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit coal"
43	6.97	35.98	49.69	7.36	2.05	.32	12550	14829
	Dry	38.68	53.41	7.92	2.20	.34	13490	
44	6.70	35.31	49.55	8.44	2.56	.02	12401	14824
	Dry	37.85	53.11	9.04	2.74	.02	13291	
45	7.03	34.78	50.27	7.92	2.48	.26	12420	14806
	Dry	37.41	54.07	8.52	2.67	.28	13359	
46	7.96	34.68	48.54	8.82	2.79	.46	12077	14741
	Dry	37.68	52.74	9.58	3.03	.50	13122	
48	7.67	33.90	50.26	8.17	2.56	.70	12234	14739
	Dry	36.72	54.43	8.85	2.77	.76	13250	
49	5.20	38.06	45.90	10.84	4.60	.59	12193	14824
	Dry	40.15	48.42	11.43	4.85	.62	12862	
Average	6.92	35.44	49.06	8.58	3.76	.39	12314	14794
	Dry	38.08	52.70	9.22	4.04	.42	13229	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —grouped according to districts.*—Continued.

DISTRICT NO. 5 GALLATIN CO., COAL NO. 5. SOUTHERN ILLINOIS.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit" coal
47	5.72	35.77	46.71	11.80	3.47	1.01	12053	14919
	Dry	37.94	49.54	12.52	3.68	1.07	12784	
Extra	4.13	34.21	52.80	8.86	3.23	.02	12987	15175
	Dry	35.68	55.07	9.25	3.37	.03	13546	
Extra	3.68	37.82	48.18	10.32	4.55	.04	12818	15078
	Dry	39.26	50.02	10.72	4.73	.05	13307	
Extra	3.94	38.13	45.95	11.98	3.53	.03	12449	15117
	Dry	39.70	47.82	12.48	3.67	.04	12958	
Extra	4.03	33.71	51.84	10.42	4.19	.02	12783	15256
	Dry	35.13	54.01	10.86	4.37	.02	13319	
Aver- age	4.30	35.93	49.08	10.69	3.79	.24	12616	15109
	Dry	37.54	51.29	11.17	3.96	.25	13183	

DISTRICT NO. 6. FRANKLIN CO., COAL NO. 6. EAST OF DUQUOIN ANTICLINE.

50	9.34	34.84	48.03	7.79	1.04	.38	12004	14633
	Dry	38.42	52.99	8.59	1.15	.42	13241	
51	10.28	33.42	49.05	7.25	1.18	.10	11890	14562
	Dry	37.26	54.66	8.08	1.32	.11	13252	
52	6.77	38.35	44.62	10.26	3.13	.91	11875	14554
		41.14	47.85	11.00	3.36	.98	12737	
53	10.18	32.78	48.88	8.16	.64	.61	11661	14419
	Dry	36.50	54.41	9.09	.71	.68	12983	
56	8.10	36.30	45.34	10.26	2.51	.74	11826	14601
	Dry	39.50	49.34	11.16	2.73	.80	12758	
57	9.67	35.69	49.55	8.54	.95	.32	11756	14529
	Dry	32.24	54.86	9.45	1.05	.35	13015	
58	8.93	34.51	48.80	7.76	.74	.36	11937	14463
	Dry	37.89	53.59	8.52	.81	.40	13108	
Aver- age	9.04	34.62	47.78	8.56	1.45	.44	11837	14538
	Dry	38.06	52.53	9.41	1.59	.48	13013	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —grouped according to districts.*—Continued.

DISTRICT NO. 6. WILLIAMSON CO., COAL NO. 6. EAST OF DUQUOIN ANTICLINE.

Co-op No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO_2	B. t. u.	"Unit Coal"
59	10.47	32.99	47.27	9.27	1.52	.38	11630	14684
	Dry	36.85	52.80	10.35	1.70	.43	12990	
60	8.22	34.00	48.79	8.99	2.16	.33	11959	14660
	Dry	37.04	53.16	9.80	2.35	.36	13030	
61	9.27	33.83	49.70	7.20	1.37	.13	12127	14671
	Dry	37.28	54.78	7.94	1.51	.14	13366	
62	9.13	33.09	49.94	7.84	1.17	.22	12028	14637
	Dry	36.42	54.95	8.63	1.29	.24	13236	
63	9.47	33.45	48.13	8.95	1.94	.36	11852	14730
	Dry	36.96	53.16	9.88	2.14	.40	13092	
64	9.34	32.77	49.48	8.41	.92	.52	11872	14577
	Dry	36.15	54.58	9.27	1.01	.57	13095	
65	9.31	33.52	48.98	8.19	1.70	.13	11919	14627
	Dry	36.96	54.01	9.03	1.88	.14	13143	
Average	9.31	33.38	48.90	8.41	1.54	.36	11913	14655
	Dry	36.81	53.92	9.27	1.70	.40	13136	
DISTRICT NO. 6. PERRY CO., COAL NO. 6. EAST OF DUQUOIN ANTICLINE.								
54	9.92	32.72	46.97	10.39	.92	.25	11335	14407
	Dry	36.81	52.15	11.53	1.02	.28	12583	
DISTRICT NO. 6. JACKSON CO., COAL NO. 6. EAST OF DUQUOIN ANTICLINE.								
55	8.96	34.44	46.40	10.20	2.65	.40	11609	14608
	Dry	37.83	50.97	11.20	2.91	.44	12751	
DISTRICT NO. 7. MACOUPIN CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.								
66	14.26	38.70	37.07	9.97	4.34	.41	10549	14236
	Dry	45.14	43.24	11.62	5.06	.48	12304	
67	14.19	37.48	38.24	9.99	3.92	.33	10558	14408
	Dry	43.68	44.57	11.75	4.57	.39	12447	
68	12.87	39.24	38.73	9.16	4.56	.30	10964	14365
	Dry	45.04	44.45	10.51	5.23	.35	12583	
69	14.20	37.40	36.95	11.45	4.42	.29	10438	14388
	Dry	43.59	43.06	13.35	5.15	.34	12165	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —Grouped according to districts.*—Continued.

DISTRICT NO. 7. MACOUPIN CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE—Concluded.

Co-op No.	Moist-ure	Volatile matter	Fixed carbon	Ash	Sul-phur	CO_2	B. t. u.	14349
Aver-age	13.88	38.20	37.75	10.17	4.31	.34	10657	Coal"
	Dry	44.36	43.83	11.81	5.00	.39	12375	"Unit

DISTRICT NO. 7. MADISON CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

70	12.81	38.67	37.40	11.12	4.80	.44	10661	14365
	Dry	44.35	42.91	12.75	5.51	.54	12227	
71	12.52	39.55	37.51	10.42	4.09	.61	10871	14421
	Dry	45.21	42.88	11.91	4.68	.70	12427	
72	13.82	37.54	38.94	9.70	4.25	.25	10722	14391
	Dry	43.56	45.19	11.25	4.93	.29	12441	
73	14.71	38.61	38.22	8.46	3.76	.28	10785	14305
	Dry	45.27	44.81	9.92	4.41	.33	12645	
Aver-age	13.47	38.59	38.03	9.91	4.22	.42	10760	143[illegible]0
	Dry	44.60	43.95	11.45	4.88	.49	12435	

DISTRICT NO. 7. SANGAMON CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

74	14.25	38.42	37.[illegible]2	10.11	4.75	.39	10556	14287
	Dry	44.80	43.42	11.79	5.54	.46	12310	
75	14.15	37.58	38.99	9.28	3.76	.45	10786	14369
	Dry	43.77	45.42	10.81	4.38	.52	12564	
Aver-age	14.20	37.99	38.11	9.70	4.26	.42	10671	14329
	Dry	44.28	44.42	11.30	4.96	.49	12437	

DISTRICT NO. 7. MONTGOMERY CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

76	13.89	37.05	38.44	10.62	3.85	.94	10574	14312
	Dry	43.04	44.64	12.32	4.47	1.10	12280	
77	14.40	36.70	39.84	9.06	3.83	.49	10709	14268
	Dry	42.88	46.54	10.58	4.47	.57	12511	
Aver-age	14.15	36.88	39.14	9.83	3.84	.70	10642	14290
	Dry	42.96	45.59	11.45	4.47	.83	12396	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —Grouped according to districts.*—Continued.

DISTRICT NO. 7. CLINTON CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

Co-op No.	Moist-ure	Volatile matter	Fixed carbon	Ash	Sul-phur	CO_2	B. t. u.	"Unit Coal"
84	12.86	37.26	39.53	10.35	4.26	.58	10755	14335
	Dry	42.76	45.36	11.88	4.89	.66	12342	
85	12.39	36.88	40.68	10.05	3.52	.72	10836	14245
	Dry	42.10	46.43	11.47	4.02	.82	12368	
Aver-age	12.62	37.08	40.10	10.20	3.90	.66	10796	14290
	Dry	42.43	45.90	11.67	4.46	.75	12355	

DISTRICT NO. 7. ST. CLAIR CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

78	11.75	38.71	38.12	11.43	3.63	.80	10874	14466
	Dry	43.86	43.19	12.95	4.11	.91	12322	
79	11.31	39.77	38.92	10.00	3.94	.63	11143	14468
	Dry	44.84	43.89	11.27	4.44	.71	12564	
80	10.04	39.33	39.09	11.54	3.91	.78	11045	14398
	Dry	43.72	43.45	12.83	4.35	.87	12278	
	11.23	40.36	38.31	10.10	4.03	.54	11126	14444
	Dry	45.47	43.17	11.39	4.54	.61	12533	
81 82	11.94	39.72	37.53	10.81	4.46	.39	10949	14510
	Dry	45.10	42.62	12.27	5.07	.45	12434	
Aver-age	11.25	39.57	38.39	10.79	3.99	.63	11028	14457
	Dry	44.59	43.26	12.15	4.50	.71	12426	

DISTRICT NO. 7. PERRY CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

88	9.61	37.09	41.27	12.03	3.70	.86	10982	14331
	Dry	41.03	45.66	13.30	4.10	.95	12150	
89	12.45	36.14	42.77	8.64	2.80	.27	11207	14431
	Dry	41.28	48.85	9.87	3.20	.31	12801	
90	10.95	37.00	41.82	10.23	3.61	.56	11060	14314
	Dry	41.55	46.96	11.50	4.05	.63	12420	
Aver-age	11.00	36.75	41.97	10.28	3.36	.56	11087	14359
	Dry	41.29	47.16	11.55	3.78	.63	12457	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —Grouped according to districts.*—Continued.

DISTRICT NO. 7. MARION CO., COAL NO. 6. WEST OF DUQUOIN ANTICLINE.

Co-op No.	Moist-ure	Volatile matter	Fixed carbon	Ash	Sul-phur	CO_2	B. t. u.	"Unit Coal"
86	11.13	38.20	39.39	11.28	3.91	.50	10964	14448
	Dry	42.98	44.32	12.70	4.40	.56	12337	
87	10.46	36.85	41.53	11.16	4.01	.42	11174	14574
	Dry	41.15	46.38	12.47	4.48	.47	12480	
Aver-age	10.79	37.53	40.46	11.22	3.96	.45	11069	14511
	Dry	42.07	45.35	12.58	4.44	.51	12408	

DISTRICT NO. 7. RANDOLPH CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE.

83	11.13	37.28	40.14	11.45	4.24	.58	10855	14351
	Dry	41.95	45.17	12.89	4.77	.65	12214	

DISTRICT NO. 8. VERMILION CO., COAL NO. 6. EASTERN ILLINOIS.

91	14.44	35.04	40.99	9.53	2.37	.66	10982	14697
	Dry	40.95	47.91	11.14	2.77	.77	12836	
92	15.59	33.47	40.16	10.78	2.33	.89	10508	14536
	Dry	39.65	47.58	12.77	2.76	1.06	12449	
93	15.19	34.95	41.55	8.31	2.04	.65	10961	14533
	Dry	41.21	48.99	9.80	2.41	.77	12925	
95	12.59	40.16	38.53	8.72	3.49	.80	11228	14532
	Dry	45.94	44.08	9.98	3.99	.92	12845	
Aver-age	14.45	35.88	40.33	9.34	2.55	.75	10920	14575
	Dry	41.94	47.14	10.92	2.98	.88	12764	

DISTRICT NO. 8. VERMILION CO., COAL NO. 7. EASTERN ILLINOIS.

94	12.69	38.78	38.89	9.64	3.34	.52	11221	14725
	Dry	44.42	44.54	11.04	3.83	.59	12852	
97	13.18	37.85	38.65	10.32	2.54	.60	11080	14754
	Dry	43.59	44.52	11.89	2.92	.69	12762	
Aver-age	12.99	38.28	38.75	9.98	2.93	.56	11143	14740
	Dry	44.00	44.53	11.47	3.37	.64	12807	

TABLE 11.—*Average analytical and heat values for separate mines and by counties —Grouped according to districts.*—**Concluded.**

DISTRICT NO. 9. LA SALLE CO., COAL NO. 7.

Co-op No.	Moist-ure	Volatile matter	Fixed carbon	Ash	Sul-phur	CO_2	B. t. u.	"Unit Coal"
99	13.56	40.87	37.80	7.77	3.68	.17	11347	14685
	Dry	47.28	43.73	8.99	4.26	.20	13127	

DISTRICT NO. 9. McLEAN CO., COAL NO. 5.

100	13.32	38.00	36.21	12.47	3.73	1.20	10580	14604
	Dry	43.84	41.78	14.38	4.30	1.39	12206	

DISTRICT NO. 9. McLEAN CO., COAL NO. 2.

100	11.26	42.21	37.73	8.80	3.03	.98	11566	14714
	Dry	47.57	42.52	9.91	3.41	1.10	13034	

EXTRA SAMPLE. LA SALLE CO., COAL NO. 5.

	14.76	41.33	34.26	9.65	3.38	.61	10692	14397
	Dry	48.49	40.19	11.32	3.97	.71	12543	

EXTRA SAMPLE. GALLATIN CO., COAL NO. 5.

	3.72	34.44	52.91	8.93	3.76	.03	13032	15187
	Dry	35.77	54.96	9.27	3.90	.03	13535	

EXTRA SAMPLE. GALLATIN CO., COAL NO. 6.

	10.82	33.83	42.43	12.92	4.93	.42	11263	15193
	Dry	37.94	47.57	14.94	5.53	.47	12629	
	4.28	36.06	49.06	10.60	3.71	.05	12583	15079
	Dry	37.67	51.25	11.08	3.88	.05	13146	
Aver-age	7.54	34.96	45.68	11.82	4.34	.23	11916	15136
	Dry	37.81	49.41	12.78	4.70	.25	12888	

EXTRA SAMPLE. MOULTRIE CO., COAL NO. 6.

	6.83	39.15	42.32	11.70	4.02	.57	11877	14882
	Dry	42.02	45.42	12.56	4.31	.61	12748	

EXTRA SAMPLE. GALLATIN CO., COAL MARKED "BELL."

	3.40	33.33	55.18	8.09	4.25	.03	13401	15420
	Dry	34.50	57.12	8.38	4.40	.03	13872	

In Table 12 calculations have been made to illustrate the use which can be made of "unit-coal" values in estimating the possible guarantees for bidding and for letting of contracts. A range of values for ash and moisture has been assumed merely for the purpose of illustration. Variations from these values, especially those in the latter part of the table, should be allowed for or calculated directly from the formula on page 41.

TABLE 12.—*Unit-coal values ranging from 14,300 to 15,000 B. t. u.*

Calculated to the "as-received" basis having normal variations of moisture, ash and sulphur, as indicated[12].

Unit coal—14,300.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 12% moisture	B. t. u. calculated to coal "as rec'd" with 14% moisture
Sangamon south of Auburn	6	10	4	10925	10639
		11	4	10771	10484
Perry	6	12	4	10616	10330
		13	4	10462	10176
Randolph	6	14	4	10308	10021
		15	4	10154	9867
Clinton	6	16	4	10000	9712
		17	4	9846	9558
Madison	6	18	4	9692	9403
		19	4	9538	9250
Montgomery	6	20	4	9384	9094
		....	....	....	....
Macoupin	6	....	....	....	....

Unit coal—14,400.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 12% moisture	B. t. u. calculated to coal "as rec'd" with 14% moisture
Logan	5	....	....	....	....
Fulton	5	....	....	....	....
Sangamon	5	10	4	11000	10712
		11	4	10844	10556
Macon	5	12	4	10688	10401
		13	4	10532	10246
St. Clair	6	14	4	10376	10091
		15	4	10220	9936
Randolph	6	16	4	10064	9781
		17	4	9908	9626
Madison	6	18	4	9752	9471
		19	4	9596	9316
Macoupin	6	20	4	9440	9161
La Salle	5	....	....	....	....

[12] For "unit coal" and method of calculation to coal "as-received" see pp. 40-42.

TABLE 12.—*Unit-coal values ranging from 14,300 to 15,000 B. t. u.*—Continued.

Unit coal—14,500.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 12% moisture	B. t. u. calculated to coal "as rec'd" with 14% moisture
Mercer	1	....	....	....	....
Bureau	2	....	....	....	....
La Salle	2	10	4	11075	10785
		11	4	10918	10628
Grundy	2	12	4	10762	10472
		13	4	10605	10315
Tazewell	5	14	4	10449	10159
		15	4	10292	10002
Menard	5	16	4	10136	9846
		17	4	9979	9689
Marion	6	18	4	9823	9533
		19	4	9666	9376
Franklin, east of Duquoin anticline	6	20	4	9510	9220
Vermilion	6	....	....	....	....

Unit coal—14,600.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 12% moisture	B. t. u. calculated to coal "as rec'd" with 14% moisture
		10	4	11150	10858
Peoria	5	11	4	10992	10700
		12	4	10835	10543
McLean	5	13	4	10677	10385
		14	4	10520	10227
Vermilion	6	15	4	10362	10070
		16	4	10205	9912
Williamson	6	17	4	10047	9754
		18	4	9890	9597
Jackson	6	19	4	9732	9439
		20	4	9575	9281

Unit coal—14,700.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 12% moisture	B. t. u. calculated to coal "as rec'd" with 14% moisture
		10	4	11225	10931
La Salle	7	11	4	11066	10772
		12	4	10907	10613
McLean	2	13	4	10748	10454
		14	4	10589	10295
Vermilion	7	15	4	10430	10136
		16	4	10271	9977
Christian	2	17	4	10112	9818
		18	4	9953	9659
Williamson	6	19	4	9794	9500
		20	4	9637	9341

TABLE 12.—*Unit-coal values ranging from 14,300 to 15,000 B. t. u.*—Concluded.

Unit coal—14,800.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 8% moisture	B. t. u. calculated to coal "as rec'd" with 10% moisture
Marshall	2	10	3	11973	11677
Jackson	2	11	3	11813	11517
Saline	5	12	3	11654	11358
		13	3	11494	11198
		14	3	11335	11036
		15	3	11175	10877
		16	3	11016	10715
		17	3	10856	10555
		18	3	10697	10395
		19	3	10537	10235
		20	3	10378	10075

Unit coal—14,900.

General location by counties	Coal bed	Ash	Sulphur	B. t. u. calculated to coal "as rec'd" with 8% moisture	B. t. u. calculated to coal "as rec'd" with 10% moisture
Moultrie	6	10	3.5	12003	11705
Gallatin	5	11	3.5	11842	11544
Saline	5	12	3.5	11683	11383
		13	3.5	11522	11222
		14	3.5	11361	11060
		15	3.5	11200	10898
		16	3.5	11038	10739
		17	3.5	10877	10578
		18	3.5	10716	10417
		19	3.5	10555	10256
		20	3.5	10394	10095

Unit coal—15,000.

General location by counties	Coal bed	Ash	Sulphur	4% moisture	6% moisture
Gallatin	5, 6	10	4	12650	12350
Saline	5	11	4	12458	12188
		12	4	12326	12026
		13	4	12164	11864
		14	4	12002	11702
		15	4	11840	11540
		16	4	11678	11378
		17	4	11516	11216
		18	4	11354	11054
		19	4	11192	10892
		20	4	11030	10730

PURCHASE AND SALE OF COAL UNDER SPECIFICATION.

PRACTICE OF STATE BOARD OF ADMINISTRATION.

Present-day tendencies relating to the basis for coal contracts are reflected in the following quotations:

When a proper sample of the coal is secured, the chemical analyses and calorimeter determinations for B. t. u. are a better guide to the value of the coal than are one or two boiler tests for the same purpose.[13]

The purchase of coal under specification is as advantageous as a definite understanding regarding the quality and other features of any other product, or of a building operation or engineering project. The man who buys under specification gets what he pays for and pays for what he gets.[14]

The heating value expressed in British thermal units per pound is the most direct measure of the value of coal. Contracts made on what is termed the "heat-unit basis" provide therefore that the amount of money paid shall be in direct proportion to the number of heat units delivered. It is evident also from what has preceded that the number of heat units varies inversely with the quantity of ash and moisture. That the bidder should be thoroughly familiar with these factors in their application to the coal which he proposes to furnish has already been emphasized. A thorough understanding of the methods of awarding contracts is also essential to the dealer who proposes to enter bids on a competitive basis.

The conditions under which bids are received, awards made, samples collected, and settlements reached, substantially as prepared for use of the Illinois State Board of Administration in the purchase of coal for the seventeen charitable institution of the State are given on page 78.

USE OF A DOUBLE STANDARD OF REFERENCE.

The cost of a given lot of coal must be based upon the weight of the material. The sample taken should represent the coal "as delivered," and, as already emphasized, moisture changes in the sample are to be carefully guarded against. Variations in quality are taken into account by varying the price per ton directly in proportion to the number of heat units delivered. In the award of contracts and in computations for payment, therefore, the calculations are based upon the heat units per pound in the coal "as delivered."

Concerning the ash, if there were no other effect produced by ash variations than a corresponding variation in the heat units then no further account would be taken of that constituent since it would be taken care of in the calculations involving the heat units. However, on ac-

[13] The Purchase of Coal: The Arthur D. Little Inc. Laboratory of Engineering Chemistry, pages 10 and 11, 1909.

[14] Pope, G. S., Purchase of coal by the government under specifications: U. S. Geol. Survey Bull. 428, page 10, 1910.

count of the expense in handling, and because of a lowering of efficiency resulting from excessive ash, an additional modification in price is made for this constituent. For greater convenience where comparisons are involved and to eliminate the moisture variable, it is found preferable to refer the ash values to the "dry-coal" basis. This involves the use of a double standard of reference; the heat units are referred to the "wet" or "as-received" basis and the ash is referred to the "dry" or "moisture-free" basis.

The methods of applying the various conditions involved, in the purchase of coal by the Illinois State Board of Administration are given as follows.

BIDS AND AWARDS.

(1). Bidders are required to specify their coal offered in terms of British thermal units "as-received," but ash is specified on the "dry-coal" basis. These values become the standards for the coal of the successful bidder.

(2). In order to compare bids, all proposals are adjusted to a common basis. The method used is to merge all three variables—ash, calorific value, and price bid per ton—into one figure. This figure will be the cost in cents of 1,000,000 British thermal units and is derived as follows.

(a). All bids are adjusted to the same ash percentage by selecting as the standard for comparison the proposal that offers coal containing the highest percentage of ash. Each 1 per cent of ash content below that of this standard will be assumed to have a positive value of 2 cents per ton, and accordingly the price will be decreased 2 cents, which is the amount of premium allowed under the contract for 1 per cent less ash than the standard established in the contract. Fractions of a per cent will be given proportional values. The adjusted bids will be figured to the nearest tenth of a cent.

(b). On the basis of the adjusted price, allowance will then be made for the varying heat values by computing the cost of 1,000,000 British thermal units for each coal offered. This determination will be made by multiplying the guaranteed British thermal units per pound by 2,000 and dividing the product by 1,000,000. This factor gives the guaranteed number of million units per ton of delivered coal. Dividing the adjusted price as found under (a) by this factor gives the cost per million heat units.

A convenient form for tabulating bids to indicate the various factors entering into the final computation of cost is shown below.

TABLE 13.—*Convenient form for tabulating bids.*

No.	Coal offered	Guarantees		Price per ton 2000 lbs.		Computed cost in cents per 1,000,000 B. t. u. ¶ (b)
		Ash in "dry coal" (per cent)	B. t. u. "as received"	As bid	As adjusted for ash ¶ (a)	
A	Vermilion Co. Screenings.........	17	10300	1.50	1.50	7.3
B	Sangamon Co. Screenings.........	16	10400	1.35	1.33	6.4
C	Williamson Co. Screenings.........	14	12500	2.00	1.94	7.8

PRICE AND PAYMENT.

Payment for coal specified in the proposal will be made upon the basis of the price therein named, which has been corrected for variations in heating value and ash from the standards specified in the contract, as follows:

(a). Considering the guaranteed heat units on the "as-received" basis, the correction in price will be a proportional one and is determined by the following formula:

$$\frac{\text{B. t. u., delivered}}{\text{B. t. u., guaranteed}} \times \text{bid price} = \text{price corrected for B. t. u.}$$

The correction is figured to the nearest tenth of a cent.

(b). For all coal that by analysis contains less ash on a dry-coal basis than the percentage guaranteed, a premium of 2 cents per ton for each whole per cent less will be paid. An increase in the ash content of 2 per cent above the standard established by the contractor is tolerated without exacting a penalty. When this excess is greater than 2 per cent, deductions are made in accordance with the following table:

TABLE 14.—*Showing deductions for excess ash*[15].

Ash as established in proposal	No deduction for limits below	Cents per ton to be deducted: 2	4	7	12	18	25	35	Maximum limits for ash
		Percentage of ash in "dry coal"							
Per cent									
5	7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	12
6	8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	13
7	9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	14
8	10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	14
9	11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	15
10	12	12-13	13-14	14-15	15-16	16-17	17-18	.....	16
11	13	13-14	14-15	15-16	16-17	17-18	18-19	.....	16
12	14	14-15	15-16	16-17	17-18	18-19	19-20	.....	17
13	15	15-16	16-17	17-18	18-19	19-20	20-21	.....	18
14	16	16-17	17-18	18-19	19-20	20-21	21-22	.....	19
15	17	17-18	18-19	19-20	20-21	21-22	.....	.....	19
16	18	18-19	19-20	20-21	21-22	22-23	.....	.....	20
17	19	19-20	20-21	21-22	22-23	.....	.....	.....	21
18	20	20-21	21-22	22-23	.....	.....	.....	.....	22

As an example of the method of determining the deduction in cents per ton for coal containing ash exceeding the standard by more than 2 per cent, suppose coal delivered on a contract guaranteeing 10 per cent ash on the "dry-coal" basis shows by analysis between 14.01 and 15 per cent (both inclusive), or, for instance, 14.55 per cent, the deduction according to the table is 7 cents per ton (reading to the right on line beginning with 10 per cent on the extreme left, which in this case is the standard, to the column containing "14.01-15," the deduction at the top of this column is seen to be 7 cents.)

NOTE—If the ash standard is an uneven percentage, the table will be revised in order to determine deductions on account of excessive ash. For example, if the ash standard is 6.53 per cent, each percentage value beginning with 6 in the left-hand column and all figures in the line reading to the right of 6 will be increased by 0.53. There would be no deduction then in price of ash in delivered coal up to and including 8.53 per cent, whereas for coal having an ash content, for instance, between 11.54 and 12.53 per cent the deduction would be 12 cents per ton.

SPECIFIC DIRECTIONS FOR SAMPLING.

Since payment for coal is based upon the quality of the coal delivered as shown by analysis of representative samples, it is imperative that

[15] Bulletin 378, United States Geological Survey, Results of Purchasing Coal under Government Specifications.

samples representing every invoice of coal be taken and that the proper officials of the various institutions see that such samples are obtained.

If desired by the coal contractor, permission will be given to him or his representative to be present and witness the collection and preparation of the sample.

TAKING THE SAMPLE.

The sample should be taken from the car during the process of unloading. An occasional half shovelful should be thrown into some receptacle such as a clean barrel or garbage can with cover so that by the time the car is unloaded, approximately 200 pounds evenly distributed throughout the load will have been taken. This will mean about one-half shovelful for every ten full scoops. They are best taken in the process of shoveling from the bottom of the car, since the top coal rolls down and mixes fairly evenly with the bottom. It should be kept in mind that in taking a sample there must be obtained the different sizes of coal, fine and coarse in their proper proportions from the entire cross section of the mass, and also an even distribution of the same lengthwise of the car. Especial care must be taken to guard against loss of moisture in the process of collecting and in reducing the gross sample.

REDUCING THE SAMPLE.

In the case of "run-of-mine" coal the largest pieces must be broken down. For this purpose empty the same upon a *clean* platform or concrete floor about 10 feet square, spread out in as thin a layer as possible, and crush with the tamper until all lumps are reduced so that none will exceed 1 inch in any diameter. Pieces of bone coal, pyrites, and other impurities should be crushed to at least ¼-inch size. Retain all of the sample on the platform, and shovel over three times in order to thoroughly mix the fine and coarse particles. Spread the coal again over the platform, and then pile into as sharp a cone as possible by throwing from the outer margin into the center. Now press out the cone with the shovel or a broom held firmly on top of the pile while moving around the same, till the mass is flattened into a circular shape about 4 inches deep. With a board or straight edge divide the mass into four equal sectors. Reject two diagonally opposite quarters.

In the case of screenings or slack no tamping to break down lumps is necessary; mix, cone and quarter as just described, throw one of the quarters into a box for determining the duff, as directed below. Thoroughly mix the sample again as at first and repeat the quartering and mixing until a sample of approximately 50 pounds has been obtained.

DETERMINATION OF PERCENTAGE OF DUFF OR DUST.

Ordinarily the percentage of fine material in screenings or slack is required; hence the determination must be made upon some part of the original sample which has not been crushed or reduced in size. For this purpose, therefore, one of the first quarters should be taken as indicated above. This quarter should be placed in a box or tub, the weight of which is known or which has been counterpoised, and the weight of the quarter carefully taken. The weight of the sample without the box should be noted on a slip of paper. From this box the material should be sifted through a screen having ¼-inch openings, and the fine material caught in a second box which has been counterpoised, or the weight of which is known. The sifted material is now weighed, and the weight of dust without the box noted on a slip of paper having the first weight. This slip bearing the two weights together with the additional memoranda note below should be inserted in the can on top of the five-pound sample before sealing, and transmitted in this form along with the coal sample.

OBTAINING A 5-POUND SAMPLE.

When the amount of the sample has been brought down by quartering to about 50 pounds the size of the particles of coal should be reduced again by grinding through a mill to ⅛-inch size. The entire 50 pounds is thus put through the mill and then through the riffle until about 5 pounds are obtained. This sample should entirely fill the can, and it is necessary to take all of a sample as obtained by the riffle. For example, if upon riffling for the last time, an amount is obtained which will more than fill the sample can, it should not be discarded, but the can should be emptied and added to the excess and re-riffled. One-half thus obtained should be put into the sample can and the other half riffled again and one of the halves thus obtained added to the sample can. Riffling in this way should be continued until the sample can is nearly or completely filled. Note especially that all dust made during grinding should receive the same treatment as the rest of the sample and not be discarded. When a sample has thus been obtained the memorandum slip showing the date, car initial and number, shipper, weight of car content, weight of quarter taken for dust, and weight of dust[16] should be put inside of can. The cap should be screwed firmly in place and sealed with electrician's tape. The name of the institution, date, number of car, kind of coal, should be carefully indicated on the can and transmitted at once to the chemical laboratory.

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[16] See suggested form for ticket on page 26.

COMPOSITING OF SAMPLES.

Compositing of the several 5-pound lots is accomplished preferably at the laboratory and should conform to the following schedule:

For contracts calling for less than 10,000 and more than 3,000 tons five car samples shall enter into the composite.

For contracts calling for less than 3,000 tons and more than 1,000 tons, samples will be taken and analyzed for each car.

The amount of each car sample taken for compositing shall be proportional to the gross car lot from which it comes, so that the assembled mass shall be composed of the same proportion of each of the several cars represented in the composite sample.

Summary of Coal Settlements under Specification for the Fiscal Year 1913-1914.

A summarized statement is given below in tabular form showing the kind of coal under contract, the guaranteed dry ash, and B.t.u. as received. The settlement prices, premiums, and penalties, as given represent the net results of the numerous settlements under each contract.

Table 15.—*Summary of coal settlements Illinois State Board of Administration fiscal year 1913-14.*

Institution	Kind of Coal	Guaranteed ash "dry"	Guaranteed B.t.u. "as rec'd"	Contract price per ton	Average settlement price per ton	Total premium	Total penalty
Anna.......	Slack	16.00	11,600	$1.49	$1.410	....	$841.00
Chicago.....	Screenings	16.00	11,620	1.94	1.942	$ 26.20	....
Chicago.....	Mine run	13.00	11,830	2.16	2.190	104.60	....
Elgin.......	Screenings	16.00	11,040	2.05	2.014	....	259.60
Jacksonville	Mine run	14.00	10,600	1.64	1.583	....	285.60
Jacksonville.	Screenings	17.00	10,500	1.40	1.296	....	515.04
Kankakee...	Mine run	15.00	11,200	1.90	1.827	....	287.74
Kankakee...	Screenings	16.00	11,350	1.70	1.655	....	703.76
Watertown..	Screenings	17.00	10,000	1.50	1.50	....	.08
Soldiers and Orphans' Home.....	Mine run	14.00	10,600	1.74	1.727	....	47.04
Soldiers' and Sailors' Home.....	Slack	17.00	9,700	1.49	1.604	445.50	....
Soldiers' and Sailors' Home.....	Mine run	14.00	10,600	1.95	1.991	10.04	....
Soldiers' and Sailors Home.....	Screenings	15.00	9,700	1.53	1.479	....	295.44

TABLE 15.—*Summary of coal settlements Illinois State Board of Administration fiscal year 1913-14*—Concluded.

Institution	Kind of Coal	Guaranteed ash "dry"	Guaranteed B. t. u. "as rec'd"	Contract price per ton	Average settlement price per ton	Total premium	Total penalty
Girls' Training School	Screenings	14.00	11,480	$2.15	$2.122	....	$110.16
Boys' Training School	Mine run	14.00	12,100	2.65	2.508	....	1,004.56
School for the Blind.	Mine run	15.00	10,700	1.70	1.685	....	28.30
School for the Deaf:.	Mine run	14.00	10,600	1.64	1.584	....	307.36
Lincoln School and Colony...	Screenings	15.00	9,700	1.16	1.229	$440.80	....
Lincoln School and Colony...	Mine run	14.00	10,600	1.35	1.272	....	46.60
Peoria......	Mine run	15.00	10,500	1.48	1.504	168.00	....
Difference							$3537.14
Totals						$1195.14	4732.28

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